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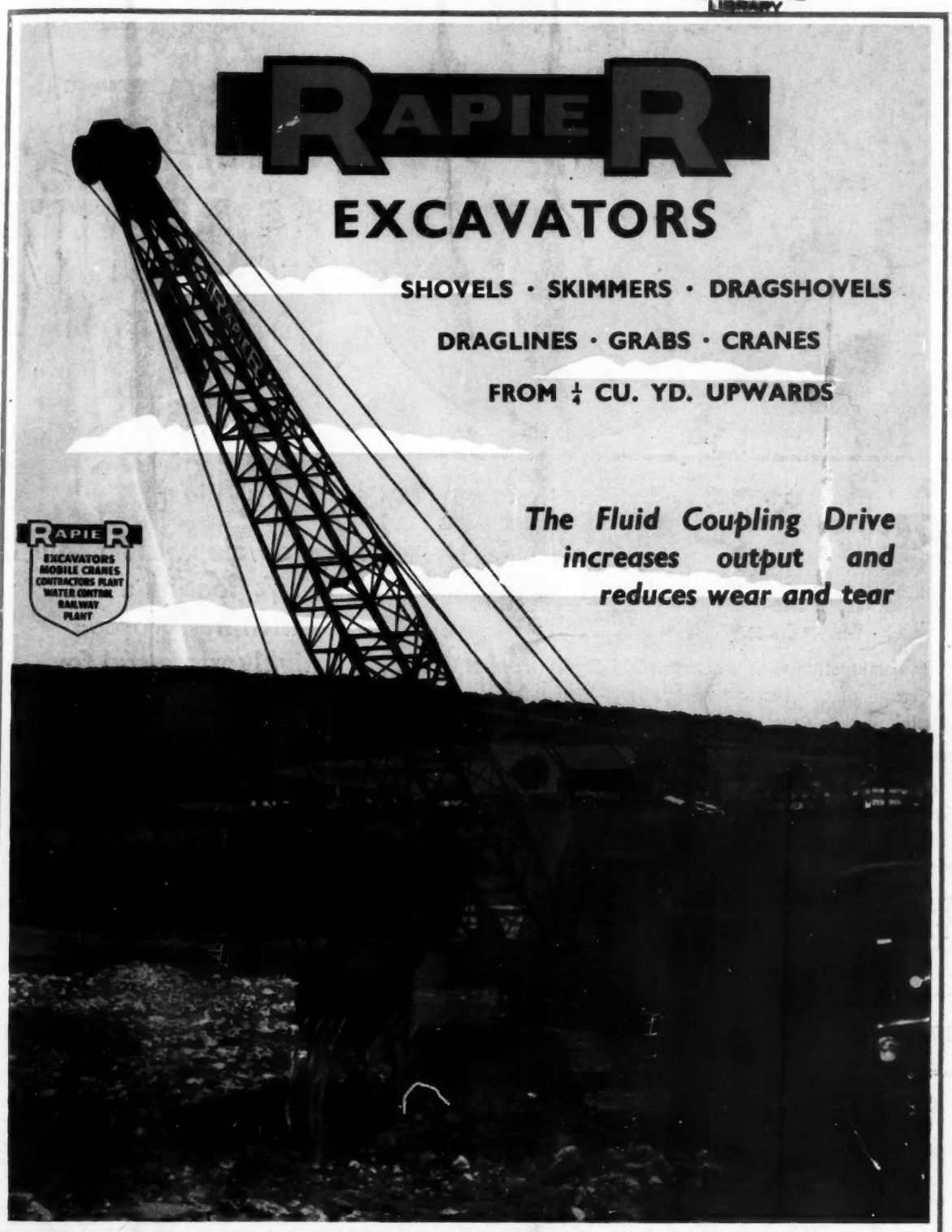

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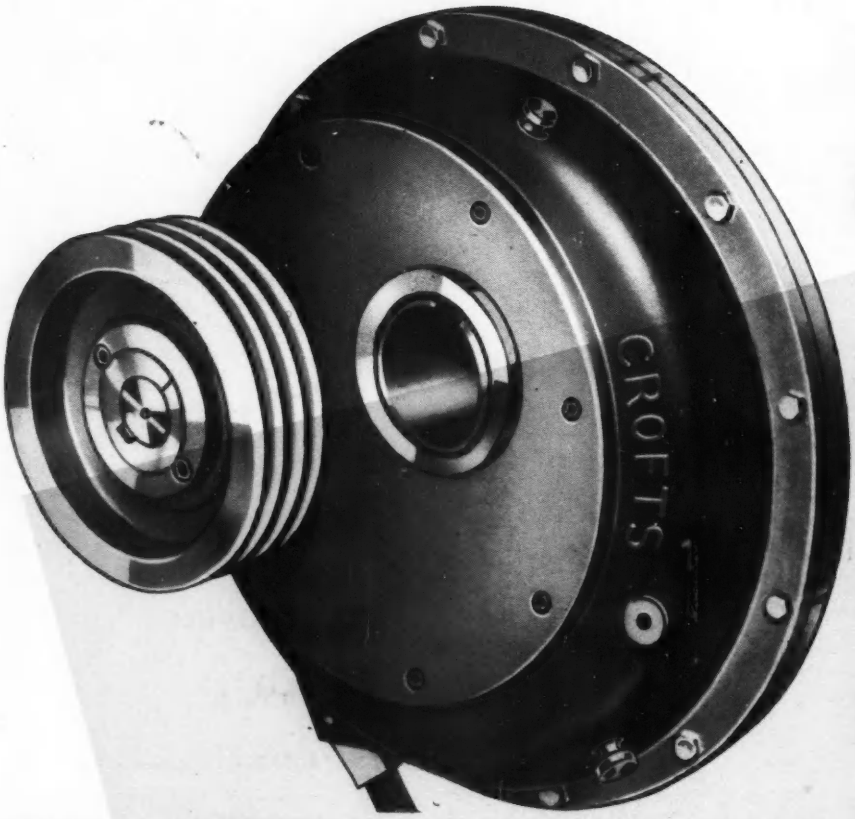

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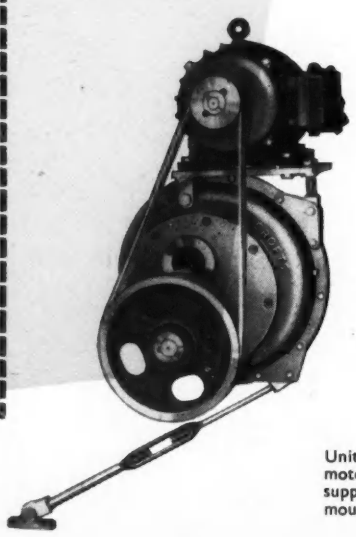

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THE ENGINEER

VOL. 202 No. 5242 JULY 13, 1956

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THE "MECHANICALS" AT EDINBURGH

The associations of Edinburgh, where the Institution of Mechanical Engineers held its summer meeting last week, are literary and historic rather than industrial. Almost pointedly, to distinguish itself from industrial Glasgow, it concentrates its outward show upon the cultural activities of mankind. Legend suggests that the city was founded in A.D. 617, when a strong place was first erected on the famous rock. That story may or may not be true. But certainly since then and, more particularly in mediæval times, owing to the perpetual wars with England, much of the city's culture was drawn directly from France and Flanders. Even as late as the eighteenth century that direct contact was renewed in the Jacobite period, rich in romantic associations with Bonnie Prince Charlie. It was towards the end of that century, after the Jacobite uprisings had been suppressed and after great roads had been driven into the Highlands so that they could be militarily controlled, that Edinburgh's modern growth of prosperity began. Then Princes Street, certainly one of the fairest streets in Europe, was laid out and new streets and squares arose to the north of it, leaving the old town, "Auld Reekie" to the south, gathered around the "Royal Mile" which connects Holyrood Palace to the great castle on its rock.

To-day, to think of Edinburgh is to think of the arts, the printing of books and of learning. The University dates back to 1583. Each year there is held in the city an international festival of music and the arts. But, away from the centre, Edinburgh conceals many interesting local industries including a number of firms whose names are world famous. Curiously, a high proportion of these industries relate to the making of things out of the usual run, things which, perhaps, in their design demand qualities of mind that are only likely to flourish in a neighbourhood closely associated with learning. Professor Arnold, in a paper he read after the opening ceremony of the summer meeting in the Assembly Rooms, when the Lord Provost, Sir John Banks, welcomed the members to Edinburgh, mentioned several of them. At nearby Leith ships are built, though none are of great size. Particularly the place is noted for its tugs—not just ordinary tugs, but those specially designed for deep sea salvage. Into a displacement of only 1630, tons, for example, there will be packed engines of 3200 h.p., so arranged with a drive through hydraulic couplings that the tug can reach a vessel in distress at high speed and then have a high thrust available for towing it to safety. Marine engineering is represented in several other ways in and about Edinburgh. Here are made those ship stabilisers that have proved so effective that almost all new liners and many existing ships are being fitted with them, and a design of hydraulic deck machinery claimed to halve, almost, the necessary power output of auxiliary generators. Steam-operated aircraft catapults, such as are now being installed on almost all aircraft carriers of the N.A.T.O. navies are built in Edinburgh. So, too, are gyroscopic gunsights for aircraft. Amongst other products that Professor Arnold mentioned were Haigh fatigue testing machines, transformers for the 275kV supergrid, and a system of computer control of machine tools. All these things and a good many others besides, members were able to see on the visits they made to various firms during their stay in Edinburgh. But, first, they had a pleasant little ceremony to perform. They were delighted at the opening ceremony to welcome into honorary membership Sir Edward Appleton, now Principal and Vice-Chancellor of Edinburgh University, and Mr. A. C. Hartley, president of the Institution four years ago.

As a summer meeting closes members are always prone to wonder where next year's meeting will be held. Traditionally the choice lies very largely in the hands of the incoming president. For very natural reasons the president tends to choose to take the members to some place with which his own work is associated. This year, for example, Mr. Crowe no doubt chose Edinburgh because it gave him the opportunity to show members the North British Locomotive Company's works, close by at Glasgow—he could hardly choose that latter city as the Institution visited it only eight years ago. There is great virtue in traditions. But they should not be allowed to harden like arteries. Times change. Owing to improved means of transport the world is shrinking in relative size and the nations are being brought closer together. Furthermore, partly as a consequence of two world wars, Britain's position in the world has changed. Britain is no longer the workshop of the world as she was when the Institution was founded. She must export her goods under the fierce competition of the industries of other nations. In these circumstances it more and more behoves the Institution to take its members often abroad to see what their competitors are doing and how they do it. And if there is one country in the

world that we think members ought to visit as soon as possible it is Western Germany, whose industries are now fully recovered from the destructive consequences of the war. We do not think, for one moment, that if the members of the Institution were taken to, say, Düsseldorf or Cologne, they would come back unimpressed by the energy with which the Germans are rebuilding their cities, their industries and their whole economy. Nor do we think they would receive anything less than a truly hospitable welcome from their competitors.

REAPPRAISAL OF BRITISH DEFENCE POLICY

It is a matter for regret that much more importance has been attached to the cuts in the Soviet Armed Forces—640,000 last year and now a further 1,200,000—than to the pronouncements made recently by Soviet leaders. Whether there are 5,000,000 or 3,000,000 men in the Soviet forces, the number is more than adequate to support a foreign policy of spreading discontent and unrest in undeveloped countries. It provides no yardstick for British defence policy. On the other hand, it is now clear from the statements of the Soviet leaders that they do not believe either East or West will resort to global war as an instrument of policy. Mr. Kruschev, while in London, went out of his way to emphasise that Russia is well supplied with nuclear weapons—an indication that the United States Strategic Air Force could no longer be used as a threat. No less significant was Mr. Bulganin's statement that " there is nowhere a possibility of war breaking out." In the absence of any change in Soviet arms, these pronouncements, taken together, confirm and strengthen the belief that the main threat to our freedom and security will come from an intensification of the cold war. The hydrogen bomb, in fact, now provides an umbrella under which the cold war can be carried out with reasonable safety. Does this not suggest a reappraisal of the British defence programme, based on closer co-operation with the United States and keeping clearly in mind what we have to guard against and what it is practicable to do within our present financial resources ? The Chancellor will, no doubt, save a proportion of his proposed cut of £100 million by closing down Scapa Flow and by other economies in the administration of the Fighting Services. But this will not solve the problem of meeting the heavy commitments envisaged in the Defence White Paper for the years immediately ahead. With the urgent need for more exports it is indeed difficult to see how we can sustain a defence budget of about £1500 million. To increase it is impossible without higher taxation or a drastic reduction in the £2000 million expended annually on the social services.

Much of the expenditure envisaged for the Army and Navy is unavoidable. War will not break out in Europe because the Western nations have stated categorically that aggression on the Continent will be resisted with every weapon at our disposal. This means that the British Army must have its armour and fire power adapted to the conditions of nuclear war. It must have equipment which is air portable and easily movable across rivers and other obstacles—all inescapable commitments, entailing a large increase in the £50,000,000 allocated in the current Estimates for tracked vehicles and guns. The Navy Estimates must equally show a substantial increase if the Royal Navy is to remain an effective force in peace and war. It is left with only twenty-one aged and war-weary cruisers, none of which could take on a " Sverdlov " class cruiser or protect herself against modern strike aircraft. Long refits and repairs have to be allowed for and the Flag has to be shown in all parts of the world—thereby often preventing a local war. Ships with anti-aircraft missiles are now being designed as replacements, but the new vessels will cost much money to build—a squadron of four may well run into £40,000,000. The need for ships of cruiser type and lesser vessels to be built with atomic power plants is also becoming all the more urgent in view of the loss of oversea bases. All these naval commitments are essential even for the cold war and limited war. Yet despite Navy Estimates of £340 million and £346 million over the past two years, expenditure on naval development and production has been reduced by over £40,000,000.

Dwarfing this impending large expenditure on the Army and Navy is the future provision to be made for the R.A.F., whose main functions are to prevent a global war and to defend this country if the deterrent fails. Remote though the danger is, global war remains a possibility. An area in the Far East or Middle East might well be regarded by both sides as a vital interest. Would the Americans again be prepared to suffer 100,000 casualties if they could be avoided by the use of nuclear weapons in the war area ? Soviet reactions would be anybody's guess. Certainly the enormous advantage gained by the power which first uses the hydrogen bomb would be kept well in mind. None the less, it is but a remote danger and our expenditure on commitments resulting solely from the existence of that danger needs the most careful consideration. At the present time we are giving priority to the deterrent —a commitment which since the war has been adequately met by the United States Strategic Air Force. Nor is there any doubt that the Americans will strive to keep it adequate. The addition of British V-bombers will in no way strengthen its restraining effect on Soviet policy. Meanwhile, though there is little official information on the subject, guided missiles are proving increasingly effective against bombing attack. Fitted with a proximity fuse and a nuclear warhead—indeed a thermo-nuclear warhead will soon be available—one guided missile would completely destroy a whole formation of bombers. Is it not in the best interests of this country, of the United States and of N.A.T.O., that the money available to guard against a remote danger should be spent on fighters and guided missiles rather than on adding to a deterrent already adequate ? Even in this hydrogen age, the British bombing force would have to be of substantial size if it is to serve a useful purpose other than prestige, in view of the large number and wide distribution of the Soviet air bases. For £250 million we could have either 500 V-bombers or 2000 interceptors armed with air-to-air missiles. Ground-to-air missiles and the modernisation of the Army and Navy would cost another £250 million. By cutting down conventional weapons and manpower to the minimum necessary for local wars we might well afford £100 million annually over the next five years for these essential commitments. Indeed, they provide legitimate ground for U.S. aid. But it will be quite impossible if we are also to spend a further £250 million, or possibly £500 million, on a force of 500 or 1000 bombers.

The Engineer

100 Years Ago

(JULY 11, 1856)

" THE SOUTH SEWERAGE "

" Sir Benjamin Hall has refused to sanction the proposal to convey the sewerage of the Surrey side to the river Thames via Plumstead Marshes, unless, as he somewhat wickedly suggests, the Act of Parliament should be amended to meet the views of our Metropolitan Board. (The hint may be of service if accepted in a proper spirit.) But we take leave to ask two questions consequent upon this refusal.

" First. Was not Sir Benjamin Hall perfectly aware all along that the scheme was being discussed by the Board, was occupying their time day after day, and that it would be presented to him for approval ? Undoubtedly he was ; would it have been derogatory to him as a sensible man, which he is generally taken to be—or to the position which he occupies, to have intimated once for all that the plan could not be sanctioned, not being in accordance with the Act of Parliament ? Such a course would not, we grant, have been consistent with the usual routine, but it would have been quite accordant with common sense and sound judgment.

" Secondly. Although the sewage cannot be turned into the river, is there any reason why the intercepting sewers should not be commenced at once ? They will be wanted at any rate, for the sewerage must be got rid of, whether we shall have to deodorise it (as at Leicester is done most effectually), or shall have to carry it further down the stream. Mr. Bazalgette's plans, as regards the intercepting sewers, are approved by the very highest engineering authority, and surely no further time should be lost before they are put in hand."

A Seven Day Journal

Human Problems of Industrial Communities

LAST Monday afternoon, H.R.H. the Duke of Edinburgh opened the Study Conference on the Human Problems of Industrial Communities within the Commonwealth and Empire, which is being held at Oxford. Preparations for the conference have been going on over the past two years. The purpose is to conduct a practical study of the human aspects of industrialisation, and in particular of those factors which make for satisfaction, efficiency and understanding, both inside industrial organisations and in the everyday relations between industry and the community around it. The conference is not dealing with matters which come within the normal scope of industrial negotiation. There are 300 representatives from all parts of the Commonwealth and Empire attending the conference. The opening ceremony took place in the Sheldonian Theatre. In his address, the Duke of Edinburgh said that the first series of conference talks were designed to set industry in its proper perspective ; they were intended to be provocative. The criterion of the subsequent study tours to be made in various industrial areas was the happiness, satisfaction and contentment of the individual as a citizen and not merely as a worker, and of communities present and future who depended for their livelihood upon industry. His Royal Highness went on to emphasise that the community was more important than industry. It might not be very easy, he said, to decide what we were aiming at in this modern world, but whatever the target, we must take into account that all people were primarily citizens, and not just workers with a bit of private life. He could see no advantage in a prosperous, powerful state if it was to be achieved at the expense of human freedom and happiness. About twenty-five " background papers " are being presented to the conference to stimulate the discussions of the twenty study groups into which the conference has been divided. From to-day until Saturday, July 21st, the representatives will be taking part in study tours in all parts of the country. The conference will reassemble at Oxford on July 22nd for further group discussions and reporting. The final gathering is to be a dinner at Christ Church on Friday, July 27th, at which H.R.H. the Duke of Edinburgh will preside.

Traffic Survey of the Cromwell Road Extension Scheme

THE British Road Federation has published a report, compiled by independent consultants, namely, Messrs. C. P. Andren and N. V. E. Seymer, in which the traffic capacity of certain road junctions of the Cromwell Road extension scheme, at present under construction, are investigated. At the Hammersmith end of the new road, the L.C.C. acquired powers to build a flyover junction, but decided that a roundabout would suffice ; the Federation was doubtful of the capacity of the roundabout system, and hence commissioned an independent investigation. The report now published is based on directional traffic surveys made during the morning rush hour. It states that the proposed roundabout is inadequate, even for present-day traffic, and will be even more inadequate by 1959, when the scheme is due to be completed. Without the flyover crossing at Hammersmith Broadway, it is stated, improvement of routes east of the Broadway would worsen rather than improve conditions at the roundabout. Inclusion of the flyover, and some other intersection improvements, are considered essential for an adequate scheme. Detailed arguments supporting these general conclusions are given in the report. The British Road Federation is also critical of the proposals at the other end of the Cromwell Road scheme where the road joins the Chiswick High Road. Here a flyover crossing is to be constructed by the Ministry of Transport and Civil Aviation, but the Ministry states that " for practical reasons " this flyover may not be completed until later than 1959, the completion date of the general scheme. If such a policy is adopted, the Federation asserts, this junction will undoubtedly constitute a major bottleneck.

Aircraft Design Mathematics

THE first production model " Deuce " computer has now been commissioned in the Mathematical Services Group of Bristol Aircraft, Ltd. The extreme speed and accuracy of this machine have been found to extend considerably the scope of design studies : one particular programme that has been prepared covers the analysis of the performance of the " Britannia " airliner for a given distance between airports, alternative landing grounds, altitudes and other variables, producing the fuel required, flight time and other answers in thirty-nine seconds. Such an estimate would require perhaps two days if done manually. An indication of the complexity of the problems which can be treated is given by the fact that the calculation of the trajectory of a vehicle for a flight of a few minutes has taken eight minutes actual computation with a word time of 32 microseconds. It is also intended to apply the computer to the analysis of data telemetered from a wind tunnel or a guided missile. The " Deuce " was referred to in THE ENGINEER of February 25, 1955. It may be recalled that it is a digital computer with a high-speed memory in the form of patterns of acoustic pulses circulating through columns of mercury and a backing store on a magnetic drum rotating at over 100 r.p.s. Other equipment in use includes I.B.M. machines to process the punched cards with which instructions, data and answers are passed to and from the " Deuce," and an analogue computer to perform flutter predictions for aircraft. This simulator is able to present graphically the response to a disturbance with up to six degrees of freedom allowed. Besides rendering possible the analysis of such complex oscillations, the analogue computer allows the effect of varying stiffness and inertia parameters to be expeditiously investigated.

Timber Research Centre

THIS week the Timber Development Association, Ltd., has been holding open days at its new research centre at Tylers Green, near Beaconsfield, Buckinghamshire. Here investigations mainly of questions of immediate interest to the timber-using industries are to be carried out, in a research programme which is complementary to that of the Forest Products Research Laboratory. The Association is making a major effort to investigate the most economic structural uses of timber, and full-scale tests were to be seen on the open days. The Association considers that timber trusses are more economical than competitive materials in spans of 40ft to 60ft. The tests now in progress are aimed at determining the most economical shape and detailing for trusses of larger span, up to 80ft or 100ft. A bowstring truss of 80ft span is at present under test; quarter-scale models of the truss are also to be tested and the results correlated with the full-scale work. An 80ft Warren girder is to be tested subsequently. Another investigation involves strength tests, with particular emphasis on the spacing of stiffeners, of a plywood box girder, 20ft long and 16in by 5in in cross section. Probably the most original tests, however, are those to be undertaken in the development of a timber shell roof. At present a quarter-scale model has been built for the first tests. The full-scale structure would be 80ft by 20ft in size, and would comprise 8ft by 4ft panels framed in 4in by 1½in timber, and bolted together ; the weight of such a " shell " roof would be only a small fraction of the corresponding concrete structure, and it would be erected without falsework. Other work includes trial applications of methods of non-destructive testing, particularly to small mass-produced timber articles where a standard test of this kind would be valuable. Two methods were to be seen, a sonic resonance test applied to testing ladder rungs, and an ultrasonic test for detecting flaws in timber.

F. J. Cowlin, O.B.E.

IT was with considerable regret that we learned of the death of Mr. F. J. Cowlin which occurred suddenly in Klagenfurt, Austria, on June 28th. Mr. Cowlin, who was sixty-five years of age, and the chief engineer of the steam turbine division of The English Electric Company, Ltd., at Rugby, had been attending the World Power Conference in Vienna. He was born in London and received his technical education at East London College, under the late Professor D. A. Low, and also at the Royal Technical College, Glasgow. He was a pupil of the late Sir Alfred Yarrow and gained the beginnings of his practical training in the yards of Yarrow and Co., Ltd., first in London and then in Glasgow. After completing his early training he joined the firm of Willans and Robinson at Rugby in 1911, where he first became associated with steam turbine development. After serving with the Royal Engineers in the first world war he returned to his old company, which was at that time about to become part of The English Electric Company, Ltd. Shortly after his return, Mr. Cowlin was appointed assistant chief draughtsman and for the next fifteen years was closely concerned with developments in steam turbines. It was during this period that the early two- and three-cylinder designs were evolved and the first 30MW, 3000 r.p.m. unit was produced. Mr. Cowlin became deputy chief engineer of the steam turbine designs department in 1937 and six years later was appointed chief engineer. In this capacity he pioneered many designs, including 200MW turbines operating at 2350 lb per square inch. He was also responsible for the designs of marine steam turbine machinery particularly for naval ships, and it was in recognition for this work that he was awarded the O.B.E. in the Honours List at the New Year. Mr. Cowlin was a member of the Institution of Mechanical Engineers and an Associate Member of the Institute of Marine Engineers.

Scientific Problems in Development of Nuclear Power

By SIR JOHN COCKCROFT, K.C.B., C.B.E., D.Sc., F.R.S.

A conference on the physics of nuclear reactors, organised by the Institute of Physics in collaboration with the British Nuclear Energy Conference, was held in London last week. The meeting was opened on Tuesday, July 3rd, by Sir John Cockcroft, president of the Institute of Physics. In his lecture, Sir John recalled that the first reactor of the Calder Hall nuclear power station reached criticality on May 22nd and that the station was expected to be delivering over 65MW of electricity to the national grid early in 1957. He went on to consider some of the problems in reactor physics, solid-state physics and chemistry, that had to be tackled in the design of C.E.A. stations using "improved" Calder Hall reactors and more advanced kinds of reactors. Abstracts from the lecture are given here.

Reactor Physics Problems

Core Structure.—The first problem to be considered by a reactor physicist in designing a new type of reactor is to determine the optimum parameters of the core. The important steps in his operations are first to assemble or measure all the relevant nuclear data—such as the fission, absorption, scattering cross-sections of atomic nuclei used in all the reactor core materials ; the number of neutrons emitted in fission per neutron absorbed by a fissile nucleus.

The second step is to make approximate calculations of core parameters to indicate the region of interest and then to make exponential experiment assemblies or zero energy critical assemblies to establish the general nuclear characteristics of the reactor system. The data from these experiments enable the methods of calculation to be refined and it is then possible to combine the nuclear calculations of the core together with heat transfer and economic analysis to design the best reactor. After this the design may be finally checked by a further zero energy experiment. In particular the effects of engineering deviations from the ideal nuclear designs are determined.

This procedure applied to the gas-cooled graphite-moderated reactor led to a lattice pitch of about 8in and a uranium rod diameter of about 1in and the canning material is a magnesium alloy "Magnox." Heat extraction rates of about 3MW (thermal) per ton are expected to be achieved in future.

An important parameter of the core is the conversion factor of U235 to plutonium, since this is one of the most important factors determining long term reactivity changes.

Reactivity Changes.—The fuel costs in power reactors are determined by the cost of uranium, the cost of fabricating fuel elements, the burn-up which can be achieved per cycle and the value of the spent fuel. The achieveable burn-up depends on the course of the reactivity changes : there is an early drop of reactivity due mainly to the formation of samarium 149 followed by a rise due to the conversion of U235 to plutonium 239. The greater the conversion factor the greater is the increase of reactivity.

As the burn-up proceeds past 1000MW-days per ton the conversion of plutonium to higher isotopes Pu 240 and Pu 241 becomes important. The cross section constants of these isotopes are not yet known accurately enough ; so far they have been determined at Harwell by using plutonium with up to 50 per cent of Pu 240. We have now built an electromagnetic separator for producing separated Pu isotopes and expect within the next year to reduce the uncertainties in the values of these constants.

Another important factor in determining long term reactivity changes is the effect of fission products of long half lives. We do not know these cross sections with sufficient accuracy and are now starting an experimental programme to improve our knowledge. We propose as a first step to extract mixed fission products from a fuel rod of a plutonium alloy which has been heavily irradiated in the Chalk River reactor. We shall then make measurements on bulk fission products. Our chemists will also separate some of the more important fission products, and cross section measurements on these will be made. We are hoping to arrange a collaboration programme with the Oak Ridge National Laboratory on this work.

A programme of this kind involves a great deal of work and special facilities. Even to cut up an irradiated plutonium rod into sections having activities of hundreds of curies requires adequate remote handling devices, whilst the cell for separation of the fission products has to be heavily shielded and to be equipped with remote handling. Facilities of this kind to work with 1000 curies of activity may cost £50,000. The operation of reactors at temperatures adequate to produce power requires a knowledge of nuclear constants at neutron energies higher than thermal. The time of flight methods using fast choppers to interrupt the neutron beams from reactors and the pulsed linear accelerator neutron source are well known. We expect to improve the accuracy of our measurements and to extend the range of these by two new developments at Harwell. The first will make use of a neutron beam from the DIDO reactor which is expected to come into use in the Autumn of this year. This will give us forty times higher intensity than we have had from BEPO. A new fast chopper operating at 48,000 r.p.m. is being built for this work and flight path of 100m will be used. Using a beam of about tens of millimetres cross section and samples of about 100 milligrammes weight we should be able to get resonance parameters up to about 100V energy, the precise value depending on the exact nature of the experiment. We are also building a more powerful electron linear accelerator. This will have an electron beam current of lamp in the pulse and an electron energy of 28MeV with a pulse width of 1/5 microseconds and repetition frequency of 400 c/s. The neutron intensity from a heavy target will be about 100 times that available from our present 15MeV linear accelerator and will be 5×10^{16} neutrons per second in the pulse. We are also planning to use a subcritical assembly of fissile material as a neutron booster to increase the intensity by a further factor of ten.

With our present inadequate knowledge of nuclear constants estimates of burn-up are uncertain by perhaps 500MW-days per ton. The achievable burn-up depends on the neutron economy and particularly on the initial conversion factor. A graphite-moderated reactor of the type likely to be used in future power stations is likely to achieve a burn-up of 2500–3000MW-days/ton.

An important corollary to this is that slight enrichment of the fuel of graphite-moderated reactors is likely to be economical. Comparatively small enrichment to increase the proportion of U235 by 3 or 4 per cent will increase reactivity and allow the burn-up to be increased. The cost of this light enrichment may be estimated by taking the U.S.A.E.C. price of U235 as a basis. A 3 per cent enrichment requires 215 grammes of U235 per ton of metal, so that the added cost at 25,000 dollars per kilogramme is about £1900 per ton of metal. This would add about 10 per cent to the cost of fuel elements. If the additional burn-up exceeds this increased cost of 10 per cent appreciably, slight enrichment would be advantageous.

Additional burn-up of fissile material in thermal reactors should be achievable by recycling the plutonium together with the greater part of the depleted uranium and feeding into the system a quantity of natural uranium to make up for the U235 burnt.

[Sir John then referred to the work done by Fenning and Syrett on the equilibrium state of a reactor operated to recycle fuel in this way.]

The overall burn-up for a recycling system depends very much on the type of reactor used and its design parameters. We expect that a gas-cooled graphite-moderated reactor with a conversion factor of 0·8 and an operating temperature of 400 deg. Cent. could achieve an overall burn-up of the order of 10,000MW-days per ton.

The burn-up likely to be achieved in an enriched fuel reactor such as the sodium graphite reactor is likely to be markedly less, especially if the reactor is operated at temperatures of about 500 deg. Cent., for this might lead to the value of η (the number of neutrons produced per fissile atom destroyed) falling to 1·65–1·70. The value of the conversion factor will, of course, depend greatly on the design and particularly on how much neutron absorbing material such as zirconium is introduced into the core for graphite canning. It will also depend markedly on the reactor size and output. Until design parameters have been specified we cannot therefore predict burn-up accurately. Nevertheless at this stage of investigation it appears that the sodium graphite reactor should be operated on the U233 thorium cycle if good burn-up is to be achieved.

An alternative way of achieving high burn-up has been pointed out by Dr. Lewis. He suggested that U235 should be burnt in reactors of high conversion ratio (0·9), such as heavy water reactors, and that by using thorium oxide fuel elements burn-up of well over 10,000MW-days per ton should be achievable so that at U.S. prices of U235 fuel costs could be reduced to the order of 1 mil.

Problems of Fast Reactors.—The problems of reactors using the upper end of the fission neutron spectrum are completely different from those of thermal reactors. The computation of critical core sizes by purely mathematical methods at first led in the U.K. to results which were uncertain to ±25 per cent. Since that time we have constructed two zero energy reactors ZEPHYR and ZEUS, fuelled by plutonium and U235 respectively, and our knowledge of the

behaviour of fast reactors has greatly increased.

Important measurements have also been made on the variation of the fissile rates throughout the core and blanket, in plutonium, U235 and U238. It was found that the fission of U238 contributes in an important way to the neutron economy of the reactor. The overall result was that in the uncooled, undermoderated ZEPHYR, breeding gains of over two were obtained. In a future high-powered plutonium fast reactor the achieved breeding gains are likely to be 1·6 and 1·7, which is very handsome. ZEPHYR work has recently shown that with a Pu core and thorium blanket 1·6 atoms of U233 are formed for each Pu atom destroyed.

Problems of Solid State Physics

Problems of solid state physics or metallurgy in nuclear reactors are of even more importance than those of nuclear physics, for the most difficult problem of all is the development of a reliable fuel element. The first group of problems is concerned with the radiation stability of fuel elements. The problems vary depending on whether we wish to use metal or oxide for the fuel elements and what the operating temperature is likely to be.

The next graphite-moderated gas-cooled reactors will operate with fuel element surface temperatures somewhat over 400 deg. Cent. Sodium graphite reactors and fast reactors will probably have metal surface temperatures of 500 deg. Cent., whilst future reactors depending on cermet or oxide fuel elements may operate at much higher temperatures.

The study of radiation damage in any new set of circumstances may easily require a total effort of at least 200 man-years. A good deal of this effort goes into the preparation of specimens having different alloy constitutions and different heat-treatments. Loops have to be prepared for containing and cooling the specimens in a testing reactor. These loops have to be provided with thermostatically controlled temperature conditions.

The low temperature radiation damage is dominated by the phenomena of the distortion of uranium. We are still very far from understanding this phenomenon though it undoubtedly results from its complicated orthorhombic crystal structure. The large scale effects can cause a uranium rod to stretch in length or to shrink several inches depending on crystal orientation. A single crystal of uranium changes its shape markedly under radiation, just as though the uranium atoms flowed through the crystal stimulated by the local heating due to the high speed fission fragments. The immediate solution to these problems for uranium fuel elements to be operated at temperatures of the order of 400 deg. Cent. is to heat treat the metal so as to reduce the grain size and to obtain random orientation of the crystals in wrought bars. This very greatly reduces the distortion of the uranium rods and it is now felt that this distortion will not be the limiting factor in the burn-up achieved in graphite reactors of the Calder or C.E.A. type.

At the high temperatures which are likely to be characteristic of the fast reactor or sodium graphite reactor the uranium is more plastic and we now encounter a different problem due to the formation of fission gases. They appear to migrate to particular localities and to form high pressure gas pockets which cause bulk swelling of the metal. We are far from understanding what decides the number and distortion of these pockets. If the metal is unrestrained the increase of volume may be as much as 40 per cent at 800 deg. Cent. An immediate experimental answer to this form of distortion may be to provide a strong container. In this way the growth may perhaps be kept down to about 5 per cent. A final answer for the fast reactor may well be to go to a liquid fuel.

Another important problem is the effect of irradiation on mechanical strength and creep. At the Geneva Conference one of the Russian papers pointed out that under irradiation, creep increased in some circumstances by a factor of the order of 1·5 to 1. Dr. Cottrell has investigated this effect by irradiating loaded uranium springs in the Harwell BEPO. He finds that during irradiation at 100 deg. Cent. the metal can creep slowly (0·1 per cent in a year) under stresses that are only about one-hundredth of the normal creep stress of the metal at that temperature. This could be important in particular reactor designs where the uranium was heavily stressed.

The effect of radiation on solid moderators is another important field. The most striking effect has been found in the irradiation of graphite. Graphite crystals grow in one direction and contract in another due to the formation of interstitial atoms by neutron impact.

The result is that bulk graphite grows by 0·05 per cent during a year in a flux of 10^{13} neutrons per square centimetre per second at a temperature of 150 deg. Cent. At the same time there are striking changes in the physical properties such as thermal conductivity, which is reduced by a factor of seven under such conditions. The effects depend strongly on temperature since at high temperatures the damage anneals out as it is produced.

Along with this so-called "Wigner growth" goes a storage of energy due to interstitial atoms. At a temperature of 100 deg. Cent. and an irradiation of one year at 10^{13} neutrons per square centimetre per second the stored energy is 110 calories per gramme; at 30 deg. Cent. it is 190 calories per gramme. A large part of this energy can be released by heating the graphite above the irradiation temperature. The graphite specimen will then show a quite spectacular spontaneous heating. We still have a great deal to learn about the storage mechanism and behaviour at high temperature—particularly about the reason why part of the stored energy does not cancel out. Different problems may arise if and when we use beryllium or beryllia moderators at high temperatures. We may be concerned here with effects arising from the formation of helium. This may build up gas pressure and lead to swelling and distortion.

Chemical Problems

As a physicist I speak with great diffidence about the chemical problems of nuclear power development, but I can emphasise their importance by saying at the outset that our chemists and chemical engineers and their problems are as numerous as our physicists and their problems.

One important group of problems is concerned with the compatibility of the materials used in reactors, particularly the compatibility of coolants with fuels and moderators and canning materials.

In gas-cooled graphite-moderated reactors the principal compatibility problem is that of the CO_2 coolant with the graphite moderator. The reaction leads to the formation of carbon monoxide and an equilibrium concentration is established. The reaction might lead to some mass transfer of carbon from one part of the reactor and its cooling circuit to another. The reaction rate increases with radiation and a loop has been operating for some time in BEPO to study the magnitude of the radiation effect. The results have shown that at the graphite temperatures we may expect in Calder Hall, and in the future C.E.A. reactors, the effects are not likely to be significant but they might prove to be a limiting factor in raising the temperature of the reactor core well beyond 400 deg. Cent. In order to make higher temperatures possible with CO_2 as a coolant it would probably be necessary to find some means of sealing the pores of the graphite.

In water-moderated reactors the principal problem is the compatibility of the hot water with the uranium fuel, for if a can develops a leak it must not be possible for a rapid attack of the fuel to take place. Experiment has shown that unalloyed uranium is attacked far too rapidly to be tolerated and if metal fuel elements are used it is necessary to resort to alloying to reduce the corrosion rate. This increases the neutron absorption markedly and a preferable alternative is to use sintered uranium oxide fuel elements, since they are very resistant to attacks by hot water.

The hot water must also be compatible with the fuel element sheath and to achieve this the U.S. have developed "Zircalloy"—an alloy of zirconium. Research is proceeding at Harwell on a range of aluminium alloys which might withstand the conditions in water reactors. If successful, these alloys would lead to a reduction in fuel element costs.

Compatibility must also be achieved with the pressure vessel and external circuit material. An obvious, but expensive, method is to use stainless steel throughout or, at least, stainless steel linings. However, stainless steel is difficult to decontaminate from fission products and it may well be possible as a result of loop tests now proceeding, and of adequate control of water conditions, to use mild steel.

In sodium-graphite reactors the hot sodium is compatible with uranium metal fuel, so one compatibility problem is removed. On the other hand, the sodium must not be allowed to penetrate the pores of the graphite or too much reactivity would be lost; so the sodium must be kept away from it. One solution which has been proposed is to can the graphite in hafnium-free zirconium sheet.

We now strike the unpleasant fact that zirconium is a very good "getter" for oxygen and so will take up any oxygen leaking into the system. Oxide leads to embrittlement and so the onus is thrown back on the designer to devise methods of keeping the oxygen content of the sodium below 10 parts per million. This difficulty may well force the designer to use a calandria design.

Compatibility problems are still more acute in the aqueous homogeneous reactor, for it has been found that the corrosion rate of the zirconium vessel holding the core fluid—uranyl sulphate—increases strongly with radiation intensity. So a search has to be made for corrosion inhibitors or other materials have to be sought which are more corrosion resistant.

In solid fuel reactors, another group of chemical problems arises from the need to recycle fuel if overall burn-ups of the order of 10,000–20,000MW-days per ton are to be achieved in future nuclear power systems. The classical aqueous solvent extraction processes are likely to be used and in large-scale plants they are likely to achieve low separation costs—of the order of £1000 per ton of uranium metal processed. This has

to be compared with an initial fuel element cost of £15,000–£20,000 per ton. The separated uranium and plutonium will now have to be refabricated under conditions under which the plutonium is contained in closed boxes, because of its toxicity. Here is a good opening for automatic remote controlled fabrication. We do not yet know the costs of refabrication under these conditions, but development work is proceeding to determine this.

Quite different chemical processing methods will be required for the breeder reactors. The fast breeder will possibly require a large number of recycles in the life of its expensive fuel owing to the severe radiation damage. Classical methods require the fuel to cool for 100 days or so to allow the radiation level to decrease. These two factors together will probably lead to unacceptably high fuel investments and processing costs, so that chemists are now working on pyro-metallurgical processes—which essentially consist of melting the fuel elements, skimming off the waste products and reforming. This is likely to be a lengthy development job.

In thermal breeders such as the aqueous homogeneous reactor and the liquid metal fuelled reactor, continuous processing of the core is possible in principle and work has been proceeding on this for some time. The fission gases, xenon and krypton, can be extracted ; their removal adds materially to the neutron economy of the system. Other fission products forming solid particles can be removed by a cyclone.

When the U.K. nuclear power stations reach an output of 20,000MW they will be producing about 6 tons a year of radioactive fission products. We can deal with the problem by evaporation and storage in large stainless steel tanks of the type we now use at Windscale. Papers at the Geneva conference, particularly from Hanford, showed that storage would contribute only 1 or 2 per cent to the cost of nuclear power.

The waste products do, however, contain radioactive isotopes, which are potentially valuable. Caesium 137, which emits a 600kV gamma ray and has a half life of thirty years, is an important example. The Windscale research laboratories are now separating caesium 137 on a pilot plant scale and the product is soon going to be used to provide kilocurie sources for radiotherapy in hospitals. Caesium might well in time replace 200kV X-rays for therapeutic treatment. Other potential applications are to industrial processes, and here sources of the order of a million curies might be available by the 1960s.

The development of these applications requires a good deal of research work by chemists and biologists. We are now building up as a close satellite of Harwell, the Wantage Radiation Laboratory, which will be equipped with powerful radiation sources, and where such research will be carried out.

You will see that the development of nuclear power requires an intensive programme of research and development continuing over at least the next two decades. At present the Atomic Energy Authority has about 1000 qualified scientists and technologists working on this development—which is a little over 2 per cent of the total research and development capacity of the country, and is about one-tenth of the U.S. effort.

The proceedings of the conference are to be published later this year by the Institute of Physics as a supplement to its *British Journal of Applied Physics*.

Radioactive Cobalt Therapy Unit

OUR illustration shows the general arrangement of the "Orbitron," a therapy equipment designed to house and apply radioactive cobalt. It will be recalled that this highly radioactive element, Cobalt 60, has a half-life of over five years with radiation energy of over 1MeV, and is a useful source of radiation for therapy.

The "Orbitron," now under construction, has been designed in collaboration by the medical and physical staff of the South Wales and Monmouthshire Radiotherapy service, Cardiff, and Newton Victor, Ltd., the X-ray department of Metropolitan-Vickers Electrical Company, Ltd. Briefly, the equipment consists of a protective container for the radioactive material, the container being mounted in an annulus, to provide all the essential movements for radiation dosage when used in conjunction with the self-contained treatment table.

"Orbitron" radioactive cobalt therapy unit under construction

The table is mounted on rails and can be rotated through 360 deg. about a vertical axis.

The Annulus

The annulus carrying the lead-filled cobalt container is motor-driven and is arranged to rotate about a horizontal axis in a floor-mounted yoke. Normally the distance of the source from the axis of the annulus is 75cm. For rotational or arc therapy the annulus can be driven at a speed which may be varied over a considerable range, but for positioning the source prior to treatment a higher fixed speed is provided. The speed control, speed indicator, position indicator and start-stop push button are in the control room. A two-position hand switch on a trailing lead in the treatment room provides rotation of the annulus at the adjustment speed or at the speed set in the control room. The speed is constant at any given setting within ±2 per cent.

The annulus can be oscillated through a preset arc at any position in the full circle, the limits of the arc of movement being preset on a dial on the side of the yoke as illustrated. Acceleration and deceleration on reversing are such that it is not, except with very narrow fields, necessary to cut off the radiation before the movement ceases, but the annulus is provided with a pair of contacts which can be set to close the shutter just prior to the end of travel and to re-open again just after the movement of the annulus has reversed. Although during rotational therapy the direction of the beam axis will usually be at right angles to the main axis of rotation, the container can, if required, be tilted so that the beam axis is inclined at any angle to this direction away from the annulus up to 90 deg. and towards the annulus up to 30 deg. A motor-driven adjustment allows the supporting arms to be adjusted to maintain the standard distance of 75cm for any angulation up to ±30 deg. to the normal.

Protective Container

The protective container is in the form of two merged spheres about 23in and 14in in diameter respectively. Space is provided to house a source of ten discs of radioactive cobalt, each 1·7cm diameter and 3mm thick, having an effective value of about 1500 curies. The protective material of the container is, however, sufficiently thick to reduce the radiation to the values given below when a total of 2000 curies is housed in the container. The cylindrical source is secured in a recess at the periphery of a protective disc which rotates in a plane at 90 deg. to the beam axis. When not in use, the source is at the centre of the larger sphere in the "protected" position. For treatment the disc is rotated through 180 deg., bringing the source to the centre of the smaller sphere in what is termed the "treatment" position.

In the "protected" position the protective material surrounding the source is sufficient to reduce the radiation to $6{\cdot}25\times10^{-3}$ r/hours at a distance of 5cm from the outer surface of the sphere. In the "treatment" position the protective material is sufficient to reduce the leakage radiation to 2×10^{-3} r/second (7·2 r/hour) at a distance of 5cm from the outer surface of the smaller sphere or beam defining device.

The source is driven by a motor from the "protected" to the "treatment" position through an arc on the annulus side of the container and, on completion of the treatment, it is returned to the "protected" position by springs. Failure of the electricity supply, or the motor, will free the source so that the springs will return it to the "protected" position ; alternatively, the source can be returned to the "protected" position manually without removing any parts or disengaging any gears. A warning light on the container indicates when the source has moved from the "protected" position. Arrival of the source at the "treatment" position starts the treatment timer which in turn, at the end of the treatment, causes the source to move back to the "protected" position. The control desk is provided with light signals which indicate that the source is in the "protected" position, in transit, or in the "treatment" position.

A mechanical indicator mounted on the main shaft of the disc which carries the source, shows clearly the position of the source at all times. The container also has a port, fitted with a beam-defining device, which varies the size and shape of the beam from a rectangle or square with a diagonal of 30cm at 75cm from the source, down to a field 2cm×2cm. The radiation limiting device can be rotated about the axis of the beam. When the source is in the "protected" position a light source projects a beam of light on to the patient's skin indicating the size and shape of the field.

A bumper provides protection for the patient and equipment. Any mechanical pressure on this bumper stops the movement of the annulus and returns the source to the "protected" position.

As can be seen from our illustration the treatment table has a shaped top which is made of radio-translucent material and is covered with sponge rubber or plastic, 1in thick. Over half the total length of the top is free from metal supports. The table is mounted on rails and moves both parallel with, and at right angles to, the annulus. Besides the ordinary manual adjustment, there are handwheels for the final delicate adjustment of both the movements, with light beams to facilitate the accurate centring of the lesion with respect to the axis of rotation. Vertical movement of the table top is provided by a motor-driven hydraulic mechanism.

Railway Oil Engines.—We are informed by Davey, Paxman and Co., Ltd., that the range of the company's 7in. by 7½in four-stroke vee engines has been readjusted to increase the maximum power from 833 b.h.p. to 1000 b.h.p. while still retaining standardisation and interchangeability of components. Fewer models cover the range from 155 b.h.p. to 1000 b.h.p. and include the four, six, eight, twelve and sixteen-cylinder naturally aspirated R.P.H. engines and the six, twelve and sixteen-cylinder pressure-charged YHX engines.

International Machine Tool Exhibition

No. IV—(*Concluded from page 12, July 6th*)

THE International Machine Tool Exhibition at Olympia ended on July 6th. Some of the exhibits are described here.

Charles Churchill and Co., Ltd.

The new "Vertimax" vertical spindle chucking lathe, illustrated in Fig. 88, and shown on the stand of Charles Churchill and Co., Ltd., Coventry Road, South Yardley, Birmingham, is designed to swing work up to 24in diameter. The machine is fitted with two hydraulically operated slides, which can be swivelled from below the horizontal to beyond the vertical position. This degree of slide movement enables the machine to carry out simultaneously, in addition to normal turning operations, two internal tapering operations, two external tapering operations, or an internal and an external machining operation. The slides, which have a maximum travel of 8½in, have an adjustment between 14in and 20in from the spindle face in both the horizontal and vertical settings.

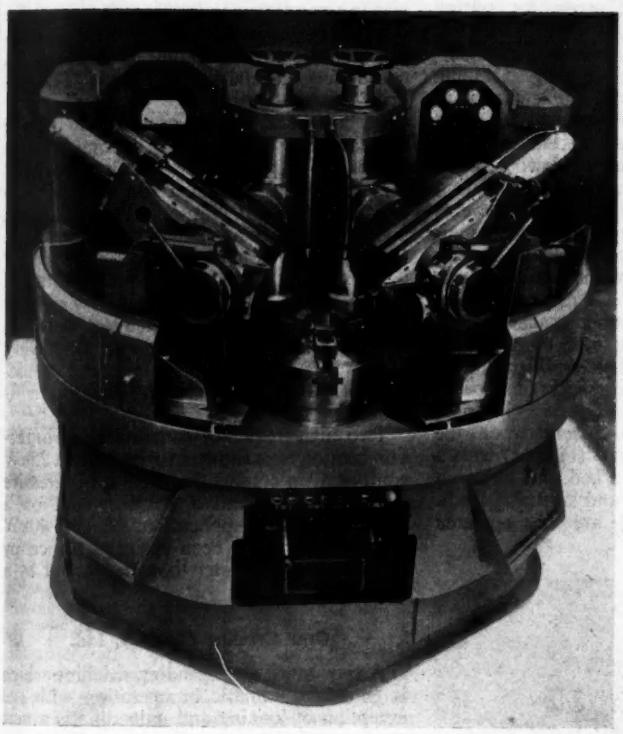


Fig. 88—"Vertimax" vertical-spindle production chucking lathe to swing work up to 24in diameter—Churchill

In the vertical position the tool slides are pneumatically balanced by air cylinders built into the round vertical columns used for locating the tool slides at the rear of the machine. This facilitates sensitive adjustment of the vertical positions of the tools with the handwheels, which are fitted with micrometer dials.

Although primarily intended for repetition work, the machine can be conveniently used for small quantities. The tool slides, besides being capable of swivelling, have an eccentric mounting and both these movements are controlled by means of micrometer dials operating through a worm and wheel arrangement. The arms carrying the slides can be moved radially and horizontally; thus the two tools can be easily and quickly set in relation to the workpiece and calibrations enable the settings to be noted for future repeats. The tool slides are fully automatic in operation. They move forward simultaneously at the start of the machining cycle with a rapid approach and then at a selected feed rate, followed by automatic retraction with the spindle stopped at the end of the cycle. The slides can also be operated by hand, using separate control levers for each slide. The machine can be fitted with a main drive motor up to 20 h.p. and has independent motors for the hydraulic supply and coolant.

A Churchill-Redman profile facing lathe exhibited swings up to 36in over the bed and its turret can be set up to 30in from the chuck. It is designed for large-diameter profile facing work and has a special swivelling profile slide mounted on the saddle cross slide. This profile slide can be indexed through 180 deg. and has mounted on it a 360 deg. compound slide and top slide assembly, which can be positioned independently as required.

There are thirty sliding and surfacing feeds and rapid power traverse to the saddle and cross slides with automatic trips is provided as standard equipment. Normally a self-indexing steel square turret is fitted to the top slide, which can carry tools for roughing out or secondary operations. When additional operations are required or the job demands it, a hexagon turret assembly can be provided as an alternative.

When the machine is used for profile facing, tracer control is obtained from a template mounted in a support on the saddle parallel with the cross slide movement. If the component has an increasing contour the profile slide is set at 45 deg. to the cross slide movement, which then allows 4in movement of the tool point. A maximum diameter of 32in can be turned at this setting. The template holder can be secured to the saddle parallel with the centre of the machine when profile turning or boring.

The model GCU 8in "Red Ring" gear-shaving machine (Fig. 89) incorporates automatic differential up-feed, conventional shaving and conventional crowning, which, together with diagonal shaving, greatly extends its usefulness. In it all the principles of rotary gear shaving practice are combined in the one machine. While the machine may be used for fixed centre distance shaving on a two-stroke cycle, it can also be set for any number of cutting strokes with or without any number of idling strokes. Up-feed of any selected amount can be obtained for each individual cutting stroke by using the automatic differential up-feed mechanism. At the end of the cycle the table automatically returns to the proper backlash position for unloading and reloading.

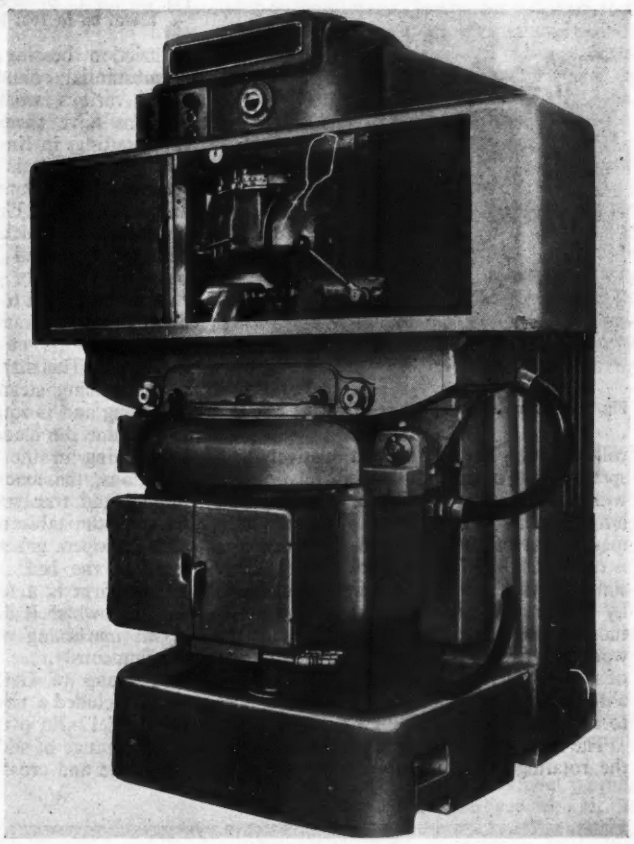


Fig. 89—8in gear-shaving machine—Churchill

For diagonal shaving a new design of work table allows the work gear to traverse at any angle from 0 deg. to 60 deg. with its axis, and when the shaving cutter width exceeds the gear width the traverse angle can be increased to 90 deg. In this way the length of work traverse is considerably reduced with a con-

sequent saving in cycle time. A fully automatic loading equipment, which permits the machine to operate continuously without stopping, is available for many kinds of gears.

Dowding and Doll, Ltd.

A number of continental machines of new and improved design were exhibited on the stand of Dowding and Doll, Ltd., 346, Kensington High Street, London, together with a group of the firm's own gear hobbing machines.

A spline rolling machine made by the Lees-Bradner Company, of the United States, is designed to generate square and involute splines on work from ½in to 10in diameter up to 10in long. On this machine (Fig. 90) the spline rolling process is accomplished by two opposed rotating heads, each carrying two freely-rotating rolls housed in vertical

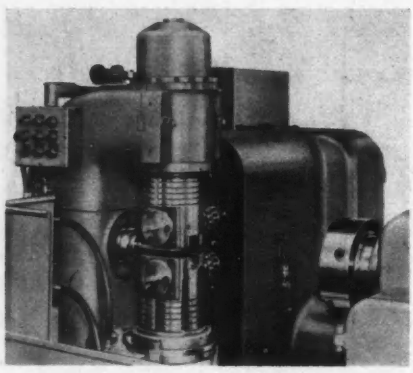


Fig. 90—Spline rolling machine—Dowding and Doll

roll carriers. The rolls turn at relatively high speeds and operate in timed relationship with the rotating workpiece as it is fed longitudinally between them. At the commencement of the operation the workpiece is rigidly held in the headstock by a chuck or similar device, and the outer end is centralised by a hydraulic tailstock centre. The longitudinal feed of the headstock traverses the workpiece axially past the rollers, the rotation of roll carrier and work spindle being synchronised according to the number of splines to be rolled.

The machine is of rugged construction and the rotating roller carriers are mounted on

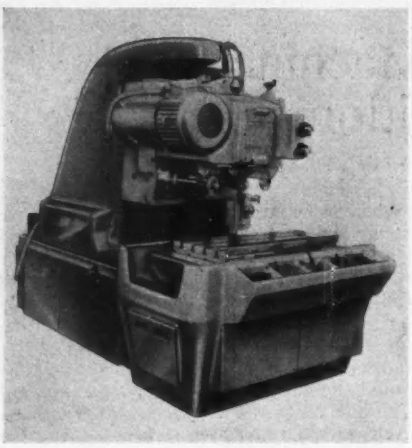


Fig. 92—Rigid copy milling machine for steam turbine blades up to 16in long—Dowding and Doll

antifriction bearings which are supported in substantial columns; they can be set to cover various workpiece diameters. The columns have annular grooves to provide rapid settings in 1in increments and the final size adjustment is made by micrometer setting. The columns can be swivelled for angular setting. The headstock is mounted on a carriage which is adjustable along the bed by a central lead screw for setting purposes.

A new addition to the Swiss-built "Rigid" automatic hydraulic copying milling machine is the model ST100/2, shown in in Fig. 92. This machine is specially intended for producing steam turbine blades up to 16in long and is equipped with two spindles to machine the blades in pairs. In addition to copying in the vertical and transverse directions, the machine incorporates longitudinal and transverse pick feeds. As can be seen the table slides on fixed bedways, and the operator's controls are grouped in front of the bed. Another machine built by this firm is a four-spindle copy milling machine, which is designed for three dimensional machining of four dies or moulds simultaneously.

A group of Oerlikon machines on the stand included a new lathe (Fig. 91) with a swing of 17·7in over the bed and having a stepless range of sliding and surfacing feeds. Its saddle and cross slide are each operated by independent motor-driven hydraulic pumps, and this feed drive is also used to provide copying facilities. The built-in hydraulic system also provides power feed operation of the tailstock quill for drilling and boring operations. For screw cutting purposes a master leadscrew can be positioned anywhere along a shaft, and when it is used in combination with a template and hydraulic feeler threads can be cut right up to a shoulder. A stepless range of spindle speeds is provided, from 38 to 2500 r.p.m.

From the range of Swiss Kellenberger machines the model 60K vertical fine boring machine was shown. This machine has a boring spindle assembly which gives full support to the boring tool throughout the whole stroke of boring depths up to 39⅜in and diameters from $\frac{7}{16}$in to 20$\frac{6}{16}$in. Boring tool diameter setting can be adjusted whilst the spindle is rotating, and this enables undercut diameters to be readily set. Table co-ordinate positioning may be by means of optical microscopes, end measuring blocks or cylindrical rods and dial indicators.

Wild-Barfield Electric Furnaces, Ltd.

A number of furnaces and high-frequency induction heating equipments, some of which are operating on a production basis, were shown by Wild-Barfield Electric Furnaces, Ltd., Watford By-pass, Watford. There was in operation a shaker hearth furnace for the continuous carbonitriding of small components as well as a complete drip-feed gas carburising installation using the "Carbodrip" system.

A horizontal batch production furnace exhibited has a chamber 56in long by 36in wide and is fitted with "Tubular Hairpin" elements. It is designed for operation up to a maximum temperature of 1150 deg. Cent. and is built to withstand the hardest usage normally to be encountered in a works' heat-treatment shop. A small self-contained electrode salt bath has a refractory pot for treatments at the more elevated temperatures, with a diameter of 6in and a depth of 9in; for lower temperature treatments and cyaniding a metal pot of larger dimensions is available.

Two high-frequency generators for induction heating were shown in operation: a 25kW equipment in conjunction with a progressive hardening unit, and a 7½kW model on a small production application. A new 40kW h.f. equipment has been designed to occupy a floor area no greater than that taken by a 15kW model.

Gear Grinding Company, Ltd.

A spur tooth gear grinding machine which is entirely automatic in operation with the exception of loading and unloading is a new product of the Gear Grinding Company, Ltd., Shirley, Birmingham. It is intended for grinding teeth from 16 to 2 D.P. on work from 2in to 24in diameter up to 8in face width. Whilst the machine is in operation the feeds are applied by a cam-actuated assembly on which the workhead is supported. Electric switches incorporated in this assembly control the overall cycle for grinding, indexing, wheel dressing and reciprocation. A new design of wheel trimming gear fitted uses a single pair of hardened and ground form plates, which are set in a predetermined position in a fixture prior to mounting on the machine.

The firm also showed one of its 20in shaft grinding machines equipped for spline grinding, a 42in spur gear grinder and some of its involute and lead measuring machines.

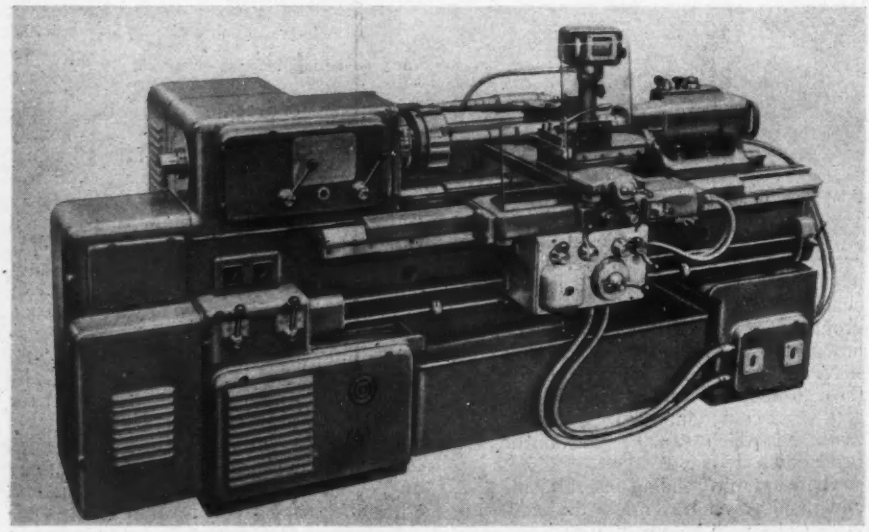


Fig. 91—Oerlikon copying lathe with stepless sliding and surfacing feeds—Dowding and Doll

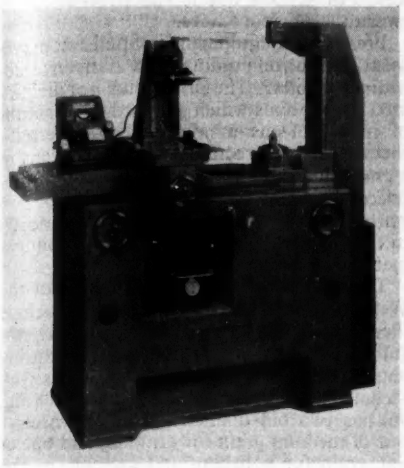


Fig. 93—Involute measuring machine for gears up to 24in diameter—Gear Grinding

The Mark IV involute measuring machine (Fig. 93) has a capacity of up to 24in work located on the main spindle and it takes smaller stem-mounted gears. This machine is similar to the firm's previous models, but it is designed to give a higher degree of accuracy and ease of operation. It is fitted with a Taylor Taylor Hobson "Talymin" electrical recording head, and a gearbox co-ordinates the traverse of the stylus with the graph paper. An amplifier unit is housed in the base of the machine. A large design of involute measuring machine shown and known as the Mark V covers components up to 42in diameter.

Gaston E. Marbaix, Ltd

A large group of machines of American and Continental design was exhibited by Gaston E. Marbaix, Ltd., Devonshire House, Vicarage Lane, London, S.W.11. The production machines included the Kummer twin-head, semi-automatic profiling lathe, shown in Fig. 94, which is intended for second operation chucking work on small components such as are used in watches, and instruments. The two heads of the lathe are of similar construction and, being independent of each other, can be used for the same or different operations.

Each head is driven by a 1·5 h.p. motor and a stepless range of spindle speeds from 325 to 2800 r.p.m. or 410 to 3500 r.p.m. is available. Work up to 2·16in outside diameter can be turned on the machine. A carriage on which two or three tools are mounted on a compound slide is traversed by cams giving a stroke of 0·787in. The carriage is spring loaded for the return stroke and for diameter turning purposes four sizing stops are available. The carriage feed cam is driven from the main drive and four feed speeds are available.

A Maegerle hydraulic surface grinder shown has a 39in longitudinal and 10½in cross traverse table and the automatic downfeed to the head can be actuated either by reversal of the cross slide or at the end of the longitudinal table cycle. This downfeed is variable between 0·0001in and 0·0005in and it is claimed that the automatic final size stop will repeat accurately to within 0·0002in. A compensating device in the head ensures that wheel wear by diamond dressing is automatically compensated for in the final size.

The head is powered for rapid traverse either up or down and a handwheel fitted on the downfeed is graduated in 0·0001in. The longitudinal table feed is adjustable between 10ft and 100ft per minute and the cross slide has both continuous and step feeds, both of which are adjustable through a wide range. The latest developments shown on this machine include cross feed measuring and locking devices, crush dressing equipment for form grinding work, a limit stop attachment in the machine base; a speed regulating set is fitted to enable spindle speeds to be selected, with automatic compensation for reduction in wheel diameter.

A Stutzmann oscillating shaving press was shown for small precision stamped components where close tolerances are to be held and a high surface finish is required on the periphery. On it a fine chip of about 0·002in is removed by an oscillating shaving process, the part entering the die under a slow pressure while the slide is vibrating at 7·3 vibrations per second. In this way shearing as opposed to cutting is precluded and the surfaces are smooth, the edges of the components remaining sharp. The stroke of vibrations is 0·004in and the machine has an effective working stroke of 0·138in on a maximum stamping periphery of $3^{5}/_{32}$in.

A range of British-built "Delta" Milwaukee drill heads shown included an American display model with "Perspex" panels in the frame so that the internal parts could be seen in operation. In these heads the air-actuated hydraulically-controlled thrust on the quill is completely independent of spindle rotation. A choice of three drives is available including direct coupling with the motor shaft, overhead pulley drive, and drive through a gear reduction unit. These alternative drives permit a wide range of spindle speeds and facilitate the building of the units into special-purpose machines, and a typical example of one of the machines was exhibited.

An 8-ton and a 25-ton automatic press, built by the Denison Engineering Company, of the United States, were shown complete with multi-station indexing tables. These machines are automatic in operation and their tables are controlled from the master valve of the main hydraulic system. Under the control system, when the table brings a station underneath the ram, the ram automatically descends with an approach speed approximately 65 per cent higher than the standard closing speed of 600in per minute, the pressing and return speeds being 250in per minute and 400in per minute respectively. The ram reverses automatically upon attaining preset pressure or against stroke length control. On reversal of the ram the table moves to the next position and the cycle is repeated. Single cycling is also obtainable, if required.

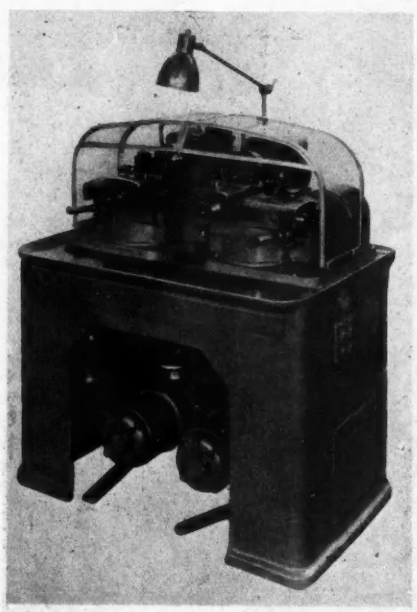


Fig. 94—Twin-head semi-automatic contouring lathe for small components—Marbaix

A British "Barnsdril" single-spindle honing machine was shown, fitted with the signal light type "Plugmatic" sizing equipment; it has a 25in stroke. Its head has pneumatic counterbalancing and the machine is equipped for automatically controlled hone expansion mechanism including automatic lift-out and a remote control wedge with electrically controlled rapid expansion. Positive depth stop and dwell mechanism is fitted.

The machine table has a finished surface of 17in by 28in area. The spindle is driven from a 5 h.p. motor and the hydraulic circuit is powered from a 3 h.p. squirrel-cage motor. The "Plugmatic" sizing equipment gives an almost entirely automatic honing operation, the only attention required being an occasional adjustment for stone wear by the operator. The honing cycle is automatic and size is held from bore to bore to within very fine limits, a signal light indicating when the final size has been reached. The machine is shown honing a 1·3745 diameter bore approximately 18in in length removing 0·003in to 0·005in stock from the bore in one operation, obtaining 20-30 micro-inches finish and holding the bore diameter size from bore to bore within 0·0005in on diameter.

Birlec, Ltd.

A recently developed high-frequency vertical hardening equipment for general-purpose work, as distinct from long production batches, was shown in operation by Birlec, Ltd., Erdington, Birmingham, 24. On this machine batches of dissimilar work can be treated as its design is suited to the rapid simple interchange of inductors and work fixtures. The equipment is so arranged that retooling can be carried out as simply as on a turret lathe.

The four-sided, rotatable work support head of the machine can carry four different workholders any one of which can be brought into action instantly.

A quick-acting contact attachment permits heating inductors to be changed without the use of tools, to suit the work. The heating head has means of vertical adjustment which facilitates quick positioning for localised heating or full traverse for progressive hardening as desired.

As work fixtures on the idle station of the rotatable head can be changed while another station is in use, no time need be lost between different batches of work.

Provision is made, when desired, for rotating a workpiece during heating, to minimise distortion of long parts, and heated parts can be quenched instantly, by multiple water jets incorporated with the inductor.

Appropriate heating and quenching time cycles are arranged by dial settings and are automatically controlled. The workhead traverse speed, for progressive hardening, is adjustable and a quick return speed is provided. The inductors used on the equipment are fabricated from solid copper, but, if required, simple heating coils made from tubing can be fitted for trial or experimental runs.

Although other sources of power are available, the surface hardening unit exhibited

is powered by a 15kW B.T.H. motor alternator, and it has a cubicle which is normally used for general purpose work, such as brazing, hardening or softening.

There was also in operation a complete high-frequency induction installation for hardening localised parts of automobile clutch sleeves, which is typical of the specialised installations manufactured by the firm for particular hardening jobs. This equipment is capable of handling 120 to 150 pieces an hour.

Stedall Machine Tool Company, Ltd.

The Lindner worm and thread grinder shown in Fig. 95 was one of the German machines demonstrated on the stand of the Stedall Machine Tool Company, Ltd., 145-156, St. John Street, London, E.C.1. This design of machine is available in different forms for high-precision single-purpose work, as a universal machine incorporating a relieving attachment and for production work. In the arrangement illustrated it has a distance of 32in between centres and grinds threads up to 20in long on work from $\frac{1}{2}$in to 8in diameter. On it, the helix angle can be set up to 40 deg. to the left or right by swivelling both the headstock and table. It is arranged for an automatic grinding cycle, and by the selection of change gears threads having a lead from 0·01in to 4$\frac{3}{4}$in can be ground.

Single or multi-rib grinding can be carried out on the machine and attachments are provided for plunge grinding.

In addition to the main grinding attachment which is provided for grinding external threads with a wheel of 14in in diameter, the machine can be equipped with an attachment suitable for small grinding wheels. This device is used for grinding internal threads and for relief grinding of straight-fluted and spiral-fluted milling cutters.

The largest of two Lindner jig boring machines shown had a 40in by 24in table and was fitted with preselection equipment and a micro-optical measuring system. Its accuracy over the entire working range is stated to be 0·00015in. The optical system uses mirror-finished cylinders on which a helical line with high pitch accuracy, serving as a graduation, is engraved. The division of the lead is done by using a graduated drum with reference to an adjacent vernier. By the optical system the sighted point of the measuring scale is projected and magnified on to projection screens on the control console of the machine where the image of the helical scale setting is centred between reference lines. For the purpose of augmenting the accuracy of positioning and in order to eliminate the factors of parallactic errors the projection system is equipped with an optical-photoelectric centering device. This device indicates the zero position when the image of scribed line is exactly centred between the reference lines.

Fig. 96—Carbide tool grinding machine with grinding and polishing wheels mounted on rotatable driving head—Stedall

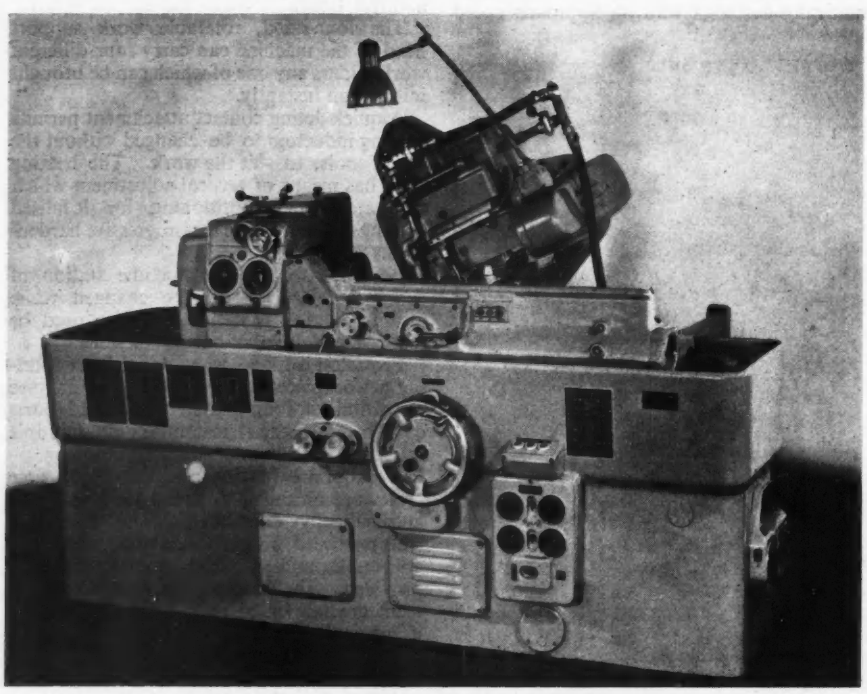


Fig. 95—Lindner worm and thread grinding machine—Stedall

Preselection equipment is fitted for movement of the longitudinal and transverse co-ordinate tables. The preselector has illuminated setting dials which are used to set tenths of inches of the amount of be traversed; further decimal fractions are set by means of a graduated drum up to 0·00004in. The preselected position is obtained by press-button starter, which moves the table automatically to the vicinity of location, final micro-adjustment being made by hand feed.

Together with an improved design of the Weydemann universal tool grinding machine there was shown one of that firm's universal cutter testers for checking all the cutting angles on milling cutters of all kinds. A Stedall carbide tool grinding machine (Fig. 96) has two 6in diameter grinding wheels—one of medium grain for grinding and one of fine grain for polishing and lapping. The wheels are mounted directly on each end of the shaft of a reversible motor, and the wheel head is turned to bring the required wheel to the working position in front of the table. This table can be set to the required angle by reference to a graduated quadrant and its setting is not altered by the turning of the wheel head.

Lumsden Machine Company, Ltd.

The only machine shown by the Lumsden Machine Company, Ltd., Hawks Road, Gateshead, 8, was a large four-head continuous grinder.

This machine consists basically of a massive column carrying four vertical heads and surrounded by a slowly moving ring table. The work passes under each head in turn as the table revolves, and is unloaded after a single revolution. The machine has been designed principally for two kinds of work. First, for large pieces, where the amount of stock to be removed is considerable, the heads are on a common radius and the work is ground by all four heads. Alternatively, the machine may be used for roughing and finishing at two levels. In this case two of the heads are moved outwards towards the edge of the table so that the part of the work ground by these passes outside the other two wheels. The machine exhibited is of this latter type and is to be used for grinding simultaneously both ends of motor-car connecting-rods.

The work is held in automatically-operated jigs or on magnetic chucks, which are demagnetised at the loading position. Each head has a 20in diameter wheel driven by a 30 h.p. motor directly coupled to the wheel spindle. The spindle is carried in preloaded high-precision bearings and the whole spindle assembly is housed in a large cylindrical ram and is overbalanced to eliminate end play. The heads are independently adjustable so that each can be set parallel to the table or tilted in any direction. Each wheelhead has a sizing device which enables the wheels to be automatically maintained at any required level irrespective of wheel wear.

The table is driven by a pinion, which meshes with a large ring fastened to the table. This pinion is driven through a worm box from an electric motor, and a step cone vee belt drive from motor to worm box gives a choice of speeds.

The column and bed, which are bolted together, are of massive section and heavily ribbed for rigidity; the column weighs 4$\frac{1}{4}$ tons and the bed 5$\frac{1}{4}$ tons.

Coolant, contained in a separate tank of 250 gallons capacity in the base of the machine, is delivered from submerged centrifugal pumps and two jets are directed at the

work at each wheel. Lubrication to all but the motors is fully automatic with individual lines to each point from pressure pumps.

A push button control panel with ammeters, indicator lights and a master stop, is fitted to the column immediately facing the operator, and the electrical control equipment is housed in a separate floor-mounting cabinet. Depending on the nature of the work to be ground, the machine can, if required, be supplied with automatic loading and "pick-off" equipment.

Elgar [Machine Tool Company, Ltd.

A large number of Continental machines were to be seen upon the stand of the Elgar Machine Tool Company, Ltd., Hampton Road West, Hanworth, Feltham, Middlesex. Amongst them there was an interesting copy-spinning and flow-forming lathe made by Bohner and Kohle, which is fitted with a hydraulic copying attachment. This machine is capable of spinning shallow components up to 84in diameter and forming work up to 39in long by 58in diameter. Its main spindle is driven by a 17½ h.p. motor and gearing at a stepless range of speeds from 10 to 600 r.p.m. An adjustable upper bed is driven by a separate 1¾ h.p. motor and is clamped hydraulically to the lower bed. The tailstock, which is adjustable on the upper bed, has a hydraulically operated quill which is clamped by hydraulic means when the quill is pressed up against the work.

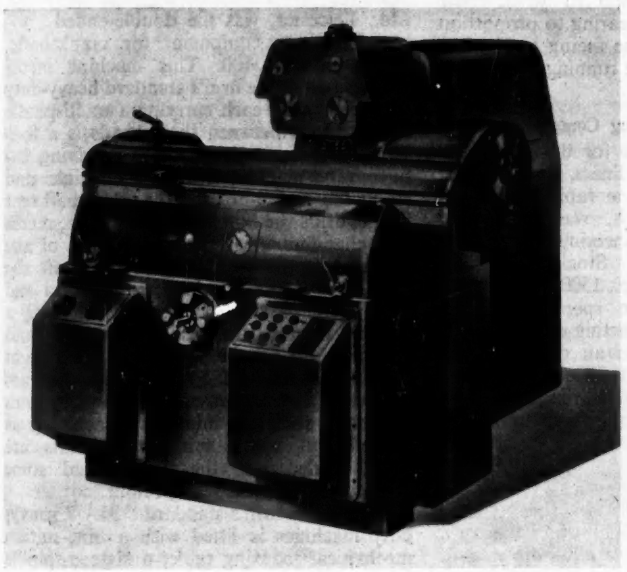


Fig. 97—Zaffenhausen automatic spline hobbing machine—Elgar

A cross slide, which is carried on a large swivelling base, is operated by a hydraulic motor and is positioned on a tee-piece by a lead screw. It is adjusted laterally by hydraulic equipment and the pressure on the spinning roll can be adjusted to suit the requirements of the work.

A Zaffenhausen automatic spline hobbing machine exhibited (Fig. 97), hobs work up to 25½in long, 6in diameter and 4 D.P. with a minimum number of four teeth. Two panels on the front of the machine carry all the control switches for setting the cutter speed and table feed, operating the motors and for controlling the automatic cycle.

For batch and mass production, the machine can be set for an automatic working cycle with a pre-set sequence of operations. The hob first starts cutting with a light feed until full depth is reached when the cutting feed is automatically engaged. When the workpiece has travelled the desired distance along the hob, the feed is disengaged and the workpiece makes a complete revolution without feed so that the ends of all splines receive a uniform run-out. The rapid power traverse then returns the table to the starting position where it remains until the appropriate switch is operated to start the next cycle.

A Heckler and Koch automatic production milling machine with a 19½in by 17in table and spindle speeds from 190 to 3000 r.p.m., is fitted with plate cams for controlling the automatic table cycle. The camshaft is driven by a gearbox and the cams can be arranged to give a wide range of automatic table cycles with controlled feed rates and rapid return motions.

Among the larger machines shown, was a Zbrojovka plano-milling machine with four-cutter heads and a 140in by 50in table with a 126in traverse. This table has a stepless range of speeds from 1in to 30in per minute, and is driven from a Ward-Leonard controlled 15 h.p. motor. Each of the two overhead and the single cutter heads on each side of the machine is driven by a two-speed 12/17 h.p. motor giving spindle speeds from 14 h.p. to 900 h.p. The cutter heads on the cross-rail can be set with centre distances from 16in to 50in apart, and the spindle noses of the two side heads can be set from 36in to 50in apart. The heads have vertical and horizontal feed rates from 1in to 20in per minute. Controls for the motions are centralised on a pendant push button panel.

Clifton and Baird, Ltd.

A heavy-duty high-speed cold sawing machine (Fig. 98), made by Clifton and Baird, Ltd., Johnstone, near Glasgow, is arranged for a fully automatic continuous cutting and feeding cycle. The machine has an 18in diameter saw and its cutting capacity covers bars from 1½in up to 5¾in diameter or 5¼in square.

The saw spindle is driven from a 5 h.p. motor through a gearbox giving three peripheral cutting speeds of 30ft, 44ft and 66ft per minute. A hydraulic cylinder which actuates the saw saddle gives an adjustable feed up to 25in per minute. A vertical work clamping vice is operated by a hydraulic cylinder through a rack and gearing, its preliminary setting being effected by a screw to within a specified distance of the work. The work feeding device consists of a hydraulically operated self-centring vice mounted on an extension bed, and having a feed stroke adjustable from ½in to 20in.

At the start of the automatic cycle the feed jaws grip the bar, which is then fed forwards the required length. The vertical vice then grips the work and the saw is fed forwards until the end of the cutting stroke, when the saddle automatically retracts and the vertical vice opens. During the cutting operation the feed jaws open and the feed saddle retracts ready for the next cycle, which starts when the work vice is fully opened. The hydraulic pumping equipment and valves for the control of the saw saddle motion are contained in the saddle itself, and driven from the main motor. The hydraulic pump and valves for the feed bench and vice motions are contained in a compartment of the extension bedplate, and this pump is driven by a separate 2 h.p. motor.

James Archdale and Co., Ltd.

The group of radial drilling machines shown by James Archdale and Co., Ltd., Worcester, included two incorporating mechanical speed preselecting equipment and one hydraulically operated. A new 5ft machine with a capacity for drilling holes up to 3in diameter in mild steel or 3½in. diameter in cast iron is fitted with a single lever on the saddle, which simultaneously locks or unlocks the saddle on the arm and the arm on the column. It has two ranges of spindle speeds from 15 to 1500 r.p.m. or 10 to 1000 r.p.m. and any speed can be preselected either with the spindle stationary or running. The twelve feeds available range from 0·002in to 0·050in or 0·004in to 0·030in per revolution and there are five tapping leads.

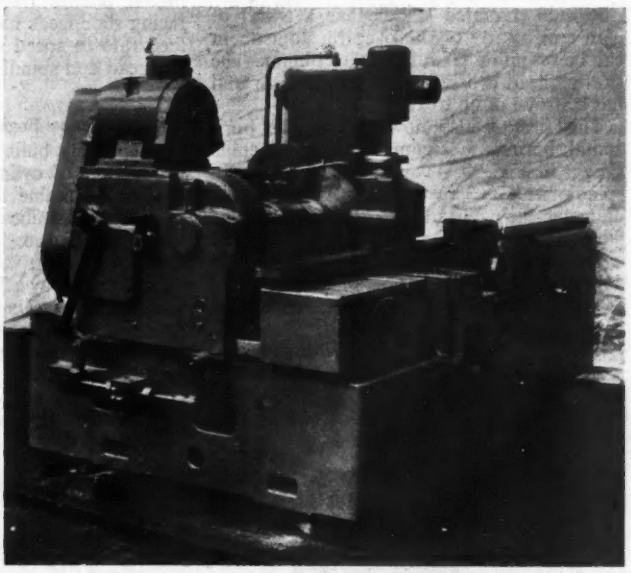


Fig. 98—Heavy-duty cold sawing machine with automatic cutting and feed cycle —Clifton and Baird

An improved 62in by 15in vertical milling machine shown for the first time has a 20 h.p. motor drive giving a speed range of 15 to 1500 r.p.m., and the drive design makes the machine particularly suitable for the use of carbide cutters or high-rate milling. An automatic feed and quick traverse motions are provided for the spindle sliding head. A magnetic clutch and brake are fitted to give gentle starting and precise control of the spindle. Twenty-four table feeds from

¾in to 45in per minute are provided and manual effort called for in vertical adjustment of the knee is reduced by the inclusion of a hydraulic counterbalance.

An example of a typical "Unimatic" standard unit work platen design transfer machine on the stand was fitted with a selection of the firm's standard self-contained hydraulic feed unit head, described in our issue of April 13th last. This transfer machine comprises two and three-station centre bed units, with loading and unloading ends incorporating platen cross indexing gear and hoists. The work heads are mounted on standard designs of extension beds and the equipment includes swarf and platen return conveyors.

Woodhouse and Mitchell, Ltd.

A new turret milling machine shown with a group of lathes by Woodhouse and Mitchell, Ltd., Brighouse, Yorks, has a 36in by 9in table with a longitudinal traverse of 24in, a cross traverse of 9in and a vertical adjustment of 17in. A 15in diameter turret, which can be rotated through 360 deg. on the column, causes the overarm in slides. On this overarm is mounted a milling head, which can be rotated through 360 deg. in the vertical plane, and, when required, a slotting attachment can be fitted at the opposite end of the arm.

The milling head is driven by a 1 h.p. motor through stepped pulleys giving a spindle speed range of 400 to 4000 r.p.m. The quill mounted spindle has a travel of 3½in and by use of the overarm adjustment can be set up to 22½in from the column. The slotting head is driven by a ½ h.p. motor and has a stroke of up to 2in.

This firm is also now making the horizontal boring, facing and milling machine shown in Fig. 99. This machine has a 3in spindle with a 30in traverse, and its 20½in diameter facing head can be used to face work up to 30in diameter. A 32in by 40in work table has a longitudinal traverse of 44in and a cross traverse of 40in., with rotary feeds from 0·035 to 0·625 r.p.m., and a rapid rotation speed of 2·5 r.p.m.

The spindle is driven by a 7½ h.p. motor and has three speed ranges The spindle alone has six high speeds from 240 to 1000 r.p.m.; the spindle and facing head together have six medium speeds from 42 to 180 r.p.m., and six low speeds from 7·5 to 32 r.p.m. If required, the spindle can be driven in the high-speed range with the facing head running at medium or low speeds. The spindle can be coupled to the facing head for the low and medium-speed ranges. Nine feed rates to the spindle, headstock, table and facing slide give 0·002in to 0·036in per revolution, or 1in to 18in per minute, or four to seventy-two threads per inch; a pick-off gear permits the use of a range of metric pitches from 6mm to ½mm. The facing slide feeds have gearing to proportion feed rate to speed of the facing head when the head and spindle are running at different speeds.

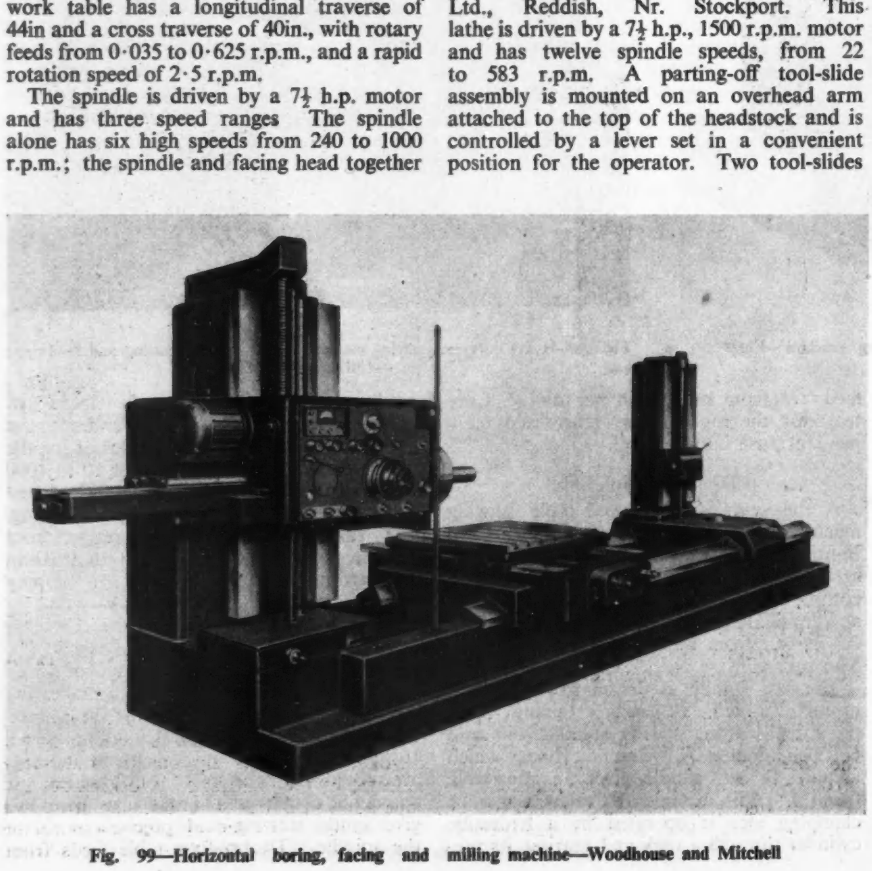


Fig. 99—Horizontal boring, facing and milling machine—Woodhouse and Mitchell

Crowthorne Engineering Company, Ltd.

A specially built lathe for the high-speed production of cylinder liners, piston rings, &c., and suitable for the rapid parting-off of bar and tube stock, was shown by the Crowthorne Engineering Company, Ltd., Reddish, Nr. Stockport. This lathe is driven by a 7½ h.p., 1500 r.p.m. motor and has twelve spindle speeds, from 22 to 583 r.p.m. A parting-off tool-slide assembly is mounted on an overhead arm attached to the top of the headstock and is controlled by a lever set in a convenient position for the operator. Two tool-slides are fitted and a fixture carrying a boring bar is mounted on the saddle adjacent to the slides. Tooling can be so arranged on this lathe that turning and boring operations can be carried out simultaneously.

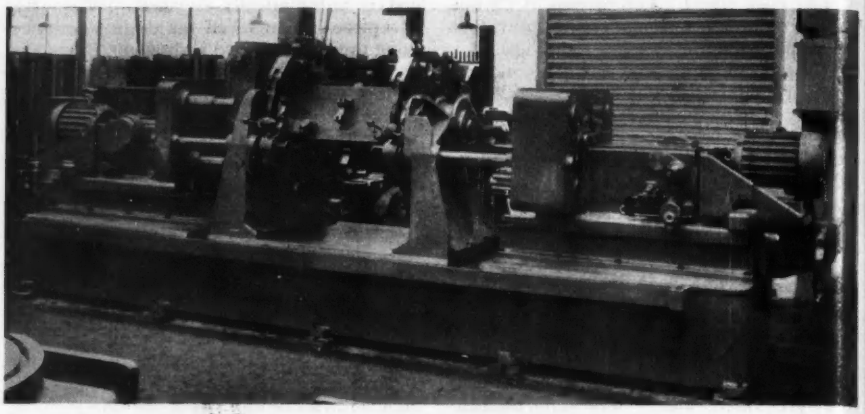


Fig. 100—Special unit-head machine for drilling, reaming, countersinking and chamfering crankshaft dog and flange ends—Pollard

Other machines shown by this firm included a 36in swing boring and facing lathe, a 12½in centre combination turret lathe and an 8½in centre lathe.

Pollard and Co., Ltd.

One of the special-purpose machines exhibited by Frederick Pollard and Co., Ltd., Leicester, was the double-ended horizontal drilling equipment for crankshafts, shown in Fig. 100. This machine incorporates two of the firm's standard heavy-duty cam feed units, each carrying a multispindle head and set between these heads is a five-station mechanically operated revolving fixture. The machine drills, countersinks and reams the dowel holes in the crankshaft rear flange, drills the bolt holes and drills, reams and chamfers the large centre hole of the flange. At the front end of the shaft the starting dog hole is drilled, core drilled and chamfered. Each of the units is driven by a 7½ h.p. motor, the head on the left-hand carrying four spindles and that on the right twenty-two spindles. All the spindles are geared to give correct cutting speeds to tools at about 50ft per minute. Machining is carried out whilst other crankshafts are being loaded into the fixture and some thirty shafts are handled an hour.

One of this firm's standard "31A" heavy-duty machines is fitted with a nine-station mechanical indexing table, a sixteen-spindle head, and special hand worm feed equipment, with a dial indicator gauge for counterboring. The fixture is designed to accommodate three kinds of bearing caps without alteration. Up to four holes are drilled in three stages in each component, which then has counterbores machined in two operations. The drills run at approximately 350 r.p.m. with cutting speeds of 50ft per minute. Operations are performed at all stations simultaneously while components are being loaded and unloaded.

Heenan and Froude, Ltd.

A cold strip forming machine, which is hydraulically operated, has been developed by Heenan and Froude, Ltd., Worcester, to simplify and speed the work involved in setting up. The operation of this hydraulic "Multiform" machine, as it is known, is controlled from a master camshaft which actuates a series of servo valves. This camshaft, which can be seen in the front of the machine in Fig. 101, is mounted between centres, and its cams operate small toggle

arms connected through cables to servo valves controlling the mechanical movements of the actual tool slides. If required, the plate cams on the shaft can be filed to alter the timing when in position on the machine, and sets of shaft-mounted cams can be readily stored for repetition batch working. The camshaft is rotated at an infinitely variable range of speeds, and the slide movements can be selected to suit particular jobs or individual slides can be cut out of operation.

The " S 1½ " " Multiform " machine illustrated takes strip up to 1½in wide and operates with a blank length up to 4in. Its front and back slides have a 1¼in stroke, and the side slides a 2in stroke, the camshaft speeds available being from 50 to 150 r.p.m. The machine has five straightening rolls fitted with a quick-opening device to facilitate the entry of the coiled strip, and the feed mechanism has a pecker design grip.

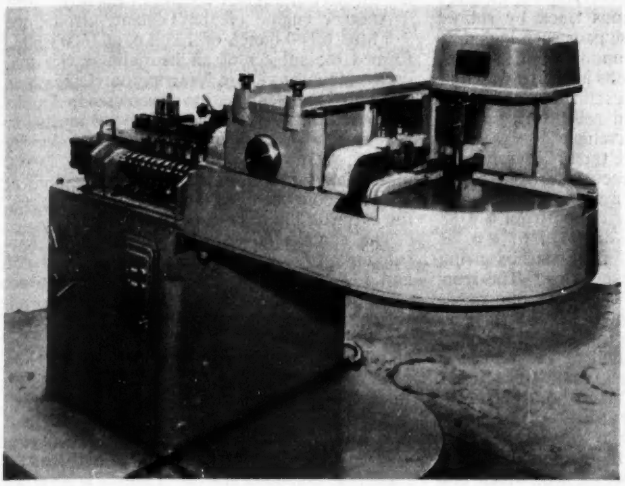


Fig. 101—" Multiform " hydraulically operated cold strip forming machine —Heenan and Froude

The stationary grip which retains the strip material after it has been fed forward is operated by a cam mounted directly on the front driving shaft. The horizontal press mechanism is of 7 tons capacity and is cam operated from the front shaft of the machine. It can be adjusted longitudinally on the bed to facilitate the tool setting.

The four cam-operated forming slides are positively controlled in both directions. These cams are assembled on mounting plates keyed to the shafts, and the cams are bolted to these plates through slotted holes so that timing of the slide movements can be effected by rotating the cams on the back plates. The centre tool slide is arranged to move away from the strip line against a return spring by forward movement of the front forming slide. A vertical stripping motion is incorporated in the centre tool head for stripping the finished formed components off the central mandrel.

Kerry Group

The products of the Kerry Group of companies—comprising Kerry's (Great Britain), Ltd., Kerry's (Engineering) Co., Ltd., Qualters and Smith Bros., Ltd., and Henry Broadbent, Ltd.—were exhibited on two stands. The equipment of Kerry's (Engineering) Co., Ltd., and Qualters and Smith Bros., Ltd., includes the well-known ranges of drills and lathes, machine saws and special machines. Demonstrations were given of the Kerry automatic high-frequency ultrasonic cleansing plant and the ultrasonic drill developed by the firm in conjunction with Mullard, Ltd.

This cleansing plant has a working frequency of 1,000,000 cycles per minute, and the articles to be cleansed are loaded into suitable trays which are placed on the loading section of the equipment, where they are automatically picked up by the conveyor system.

The trays pass into a pre-wash tank, which serves to loosen and remove gross contamination. From this section they travel on to the ultrasonic section and are halted directly over a multiple transducer array of rectangular barium titanate plates. Here the dwell period can be varied by the setting of a calibrated dial between two seconds and two minutes, the usual period being fifteen to twenty seconds.

The ultrasonic tank is supplied with clean filtered solvent, which circulates at a rate of 400 gallons per hour. Multiple filters in the pumping circuit remove particles down to one micron. In addition, the solvent is constantly replaced by redistilled fluid so that the finer particles below one micron are removed, together with oil dissolved from the cleaned articles. The trays then proceed to a vapour still, where the temperature of the articles is raised so that as they emerge through the cool zone of the still the solvent evaporates. The baskets are then automatically off-loaded from the conveyor with the contents clean and dry.

The transducers in the equipment are totally immersed so that they can be operated at high power levels without danger of overheating, and the energy density in the forward direction from the transducers is approximately 10W per square centimetre. The high operating frequency used enables thin plates to be employed with consequent reduction in temperature gradients within the crystals. The transducers are supplied from a single generator specially designed by Mullard, Ltd., for operation with barium titanate transducers. This 5kW generator is rated for full-load continuous duty operation with an output power of 2kW at 1 megacycle.

The high stability of output power and frequency obtained from this generator simplifies operation of the cleaner. As soon as thermal equilibrium has been attained in the ultrasonic tank, no generator frequency adjustments are required. In practice the frequency is adjusted on first switching on and corrected to its final value after about thirty minutes' operation. In many cases the correction required is so small that the frequency can be left permanently set to the correct value for long term operation.

The ultrasonic drilling equipment has been designed for the machining of hard and brittle materials such as hardened tool steels, mineral and precious stones. The machine produces a vertical reciprocating motion of the drilling tool at a rate of about 20,000 c/s. Rapid cutting is achieved by the repeated light chipping action of an abrasive slurry which is interposed between the cutting tool and the workpiece. The shape of the cut closely follows that of the tool, which is normally made of a soft material such as brass or mild steel, which cannot readily be chipped. The machine is stated to be capable of cutting a ¼in diameter circular hole ¼in deep in soda glass in thirty seconds, and in tungsten carbide in fourteen minutes, with a solid tool. Drilling speed is generally increased by using a hollow, or trepanning, tool.

The equipment comprises two units : a drill pedestal and an ultrasonic generator. The pedestal incorporates a drill head and counterbalance weight, an abrasive slurry pump and a table on which the work is clamped. The drill head consists of a water-cooled magnetostrictive transducer to which is coupled an exponential horn which amplifies the motion produced by the magnetostriction effect. The design of the drill head follows standard machine tool practice with regard to the location of controls, and the ultrasonic power is generated in a standard Mullard 2kW generator.

Hordern, Mason and Edwards, Ltd.

The 100-ton open-front, geared press, illustrated in Fig. 102, is the largest machine of a range of seven new open-front presses made by Hordern, Mason and Edwards, Ltd., Tyburn, Birmingham. It is driven by a 7½ h.p., 1455 r.p.m. motor giving forty strokes a minute. Its maximum fixed stroke is 8in and there are six variable strokes from 1in to 6in.

If required, an air-balanced slide can be fitted to facilitate tool setting where a supply of compressed air is available, and a pneumatic die cushion equipment can be supplied for the machine. The clutch can be adjusted for non-repeat operation or continuous running when the pedal is locked down. Stroke adjustments are quickly and easily effected by the removal of a locking pin and operation of a lock ring and bush using two tommy bars. All the principal points on the press are arranged for " one-shot " lubrica-

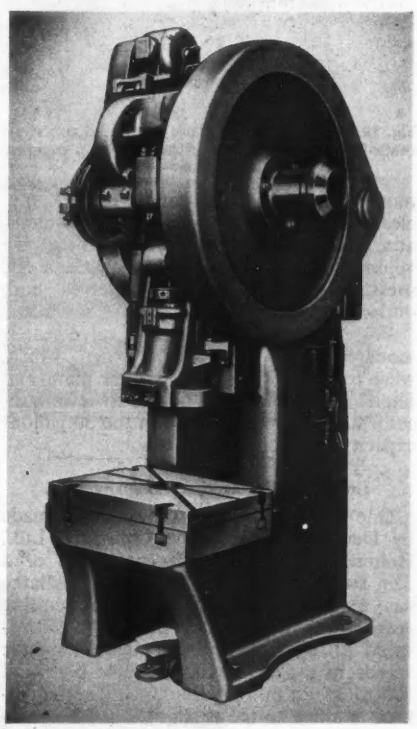


Fig. 102—100-ton open-front geared press—Horden, Mason and Edwards

tion through a hand lever operated pump, to be seen on the side of the machine in the illustration.

An automatic coil feed equipment, recently introduced by the firm, can be fitted in place of the 40in by 29in bolster. Double or single feed rolls to take stock up to 9in wide can be fitted on the attachment which can feed from left to right or from right to left, as required.

Keelavite Rotary Pumps and Motors, Ltd.

A hydraulic power pack for use on machine tools now being made by Keelavite Rotary Pumps and Motors, Ltd., Allesley, Coventry, has all the hydraulic equipment, including the pump, filter, air cleaner, pressure control, volume control and recording instruments built into the tank. This composite power and control assembly is designed to simplify and centralise the installation of the hydraulic equipment in a machine.

These power packs are assembled from standard hydraulic units and the typical equipment illustrated in Fig. 94 incorporates a 7 g.p.m., 1500 lb per square inch capacity

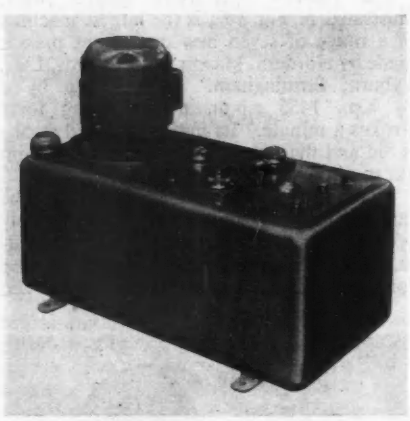


Fig. 103—Hydraulic power jack housing all power and control gear and recording instruments for a complete hydraulic installation—Keelavite

pump driven at 1430 r.p.m. by a 3 h.p. electric motor. Two pressure outlet lines are used, each being fitted with its own volume (speed) control valve, whilst a single pressure control and gauge serves both outlet lines.

For ease in servicing, all the valve gear is mounted on a detachable panel which, when removed, allows access to the pump and filter. An air cleaner and an oil level indicator are also incorporated in the 30 gallons capacity reservoir.

Denham's Engineering Company, Ltd.

One of the three new centre lathes made by Denham's Engineering Company, Ltd., Holmfield, Halifax, is the prototype of a 22in swing heavy-duty machine. This lathe has a fifty-four change feed/screwcutting gearbox and its headstock, powered by a two-speed 20/10 h.p. motor, has eighteen spindle speeds in ranges of 1000 to 30 r.p.m. and 500 to 15 r.p.m. Hydraulic copying equipment is fitted to the machine.

A 14¾in centre machine shown is equipped with heavy-duty built-in copying front tool slides. This machine, using longitudinal feed, is designed to swing and profile twin components up to 16in diameter by 10ft long. It can also be supplied with a gap bed, when it will swing work up to 50in diameter by 18in wide, and will profile work up to 42in long to a depth of 4½in. In addition to copy turning the machine can be used for normal centre duties.

Oil-Engined Vehicles

THE Canadian Government is to experiment with an Albion-Cuthbertson "Water Buffalo" for transport over boggy terrain in the far North of Canada. This tractor, which is shown in our illustration, is well adapted to soft going, since it crawls on tracks 24in, 30in or 36in wide, with a ground pressure of only 2¼ lb per square inch in the latter case. These tracks are, in effect, flexible, so that on uneven ground they do not rest solely on high spots. Steel plates carrying the driving dogs and others carrying the grousers are linked into a continuous track by rubber pads about ¼in thick : these pads each include a continuous steel cable wound round ferrules surrounding the securing bolts in such a way that the tension in the track is sustained by the cable. Sprung groups of balanced rollers are used to spread the weight of the vehicle over a large part of the lower run of the track. Power is fed to the front sprocket at each side by a worm and wheel driven through a steering clutch and brake unit : these are gear driven from a 4·88 litre Albion four cylinder diesel of 67 h.p. at 1800 r.p.m. with a constant mesh gearbox giving five forward and one reverse ratios. The rearmost roller incorporates a simple adjustment for track tension, the pin in which will shear in the event of large stones trapped inside overstressing the track. The hull of the vehicle is waterproof, and it will wade in up to 4ft of water. A winch can be fitted, and an anchor can be used to help extricate the vehicle if it is bogged down: the tracks can be driven while winching, and the smooth under-surface of the hull allows it to skid over the mud or sand. Using winch and tracks together, extreme draw-bar pulls can be reached.

The maximum speed of the tractor is 8·5 m.p.h. and it can easily surmount a one-in-one gradient. Loads up to three tons can be carried on the "deck" above the tracks. The crawler is 13ft long, and on hard ground has a clearance of 16½in. The Canadian vehicle will be used to tow high-sided sleds, while others have been applied to drainage, scrub clearance, pipe and cable laying, and survey work in marsh land.

The "Water Buffalo" weighs 17,500 lb and has a maximum tractive effort of 19,000 lb

Another recent exploitation of the diesel automotive power unit is the oil well perforating unit which has been placed in service by Trinidad Oilfield Service, Ltd. This has a Leyland "Comet" chassis, similar to that of the mobile cementer which lines the bores of oil wells, and is used to pierce the cement casing in way of the oil-bearing sands. The gun used contains twenty-four shots, and a typical well would call for 144 perforations, 3in apart, at a depth of 6000ft. Thus a great deal of hoisting is required, and high winch powers are needed to save time. The gun, which is 12ft long, is carried on a ⅞in single core wire, some 17,000ft being spooled on the winch. Lowering is by gravity against a winch brake, and the depth of the firing point is determined by a line measuring device.

The Albion main gearbox is followed by the gearbox of a "Super Hippo," which incorporates a power take-off able to handle the full engine output, and this drives the winch through a Warner transmission. The winch operator is located in a separate cabin behind the driver, who is in the normal control position. This winch unit is also used for hoisting instruments in the shaft for such purposes as collar locating ; in these cases the indirect ratios of Albion and Warner transmissions are used to obtain close control of the line speeds.

Another engine of the Leyland Group, the 9·8 litre 0/600 diesel, of 125 h.p. at 1600 r.p.m., formed the subject of an heuristic service trial on omnibus service in Warrington, Lancashire. Twenty of these engines have been used in double-deck vehicles on services involving much low gear work and idling at level crossings and swing bridges. One which had completed 300,000 miles running, consuming $2{\cdot}87\times10^6$ gallons of fuel, has now been dismantled in order to assess the overhaul life to be expected in service.

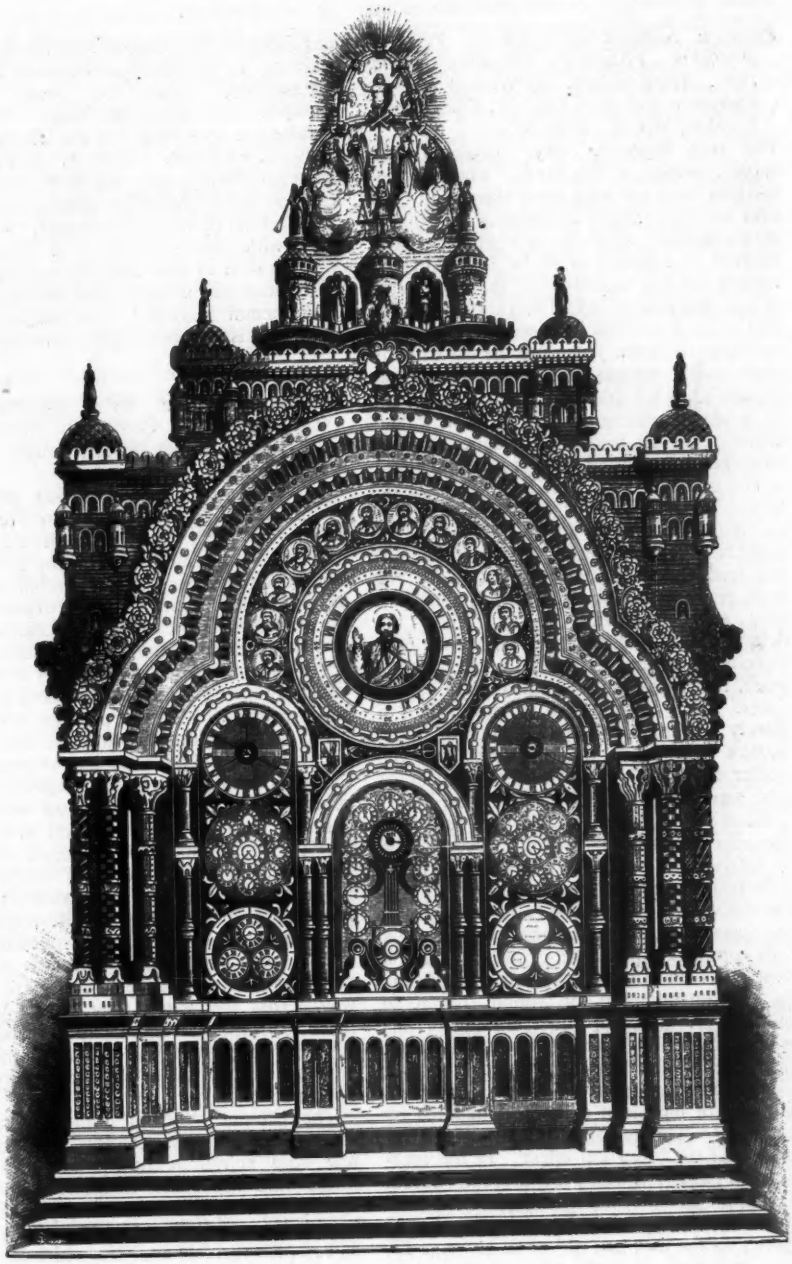
The engines have been running on a low-sulphur oil fuel with a Diesel index between 51 and 57, and a sulphur content below 0·06 per cent. The lubricant was a straight mineral oil, solvent processed and without inhibitors ; it was reclaimed after use. It was renewed every 5000 miles, and at alternate changes the injectors were replaced and the o.h.v. gear checked over. Fuel pump servicing was performed when invited by consumption records or smoke at the exhaust. No other work had been done on the engine.

On a dynamometer test it was found that the fuel pump and governor were faulty, the governed maximum having fallen to 92·4 h.p. at 1600 r.p.m. The pistons and combustion chambers were sufficiently clear of carbon for stamped part numbers to be visible. Exhaust valve stems had worn as much as 0·004in, but the "Stellite" faces were fit for further service. The outer valve springs complied with tests for new springs, and only one inner spring had reached the rejection threshold for used springs. Piston rings were all free in their grooves, but gaps had doubled to about 0·05in, and in one case risen to 0·14in. The drain holes leading away from the scraper ring groove were all blocked with carbon, and there was some scoring near the top of the pistons opposite the thrust face. The most oval cylinder bore had worn at a rate of 35,000 miles per 0·001in wear. The gudgeon-pins were tight, and the connecting-rod bearings within the tolerances for new parts, as also were all crankshaft journals. The main bearings showed a maximum ovality of 0·001in. The camshaft was also within its original tolerance envelope, and its bearings did not need renewal. The camshaft end float was 0·047 against a permitted 0·010, and the thrust washer was renewed ; this can be done with the engine installed. The timing gears had less than 0·01in backlash, and the oil pump gears were fully serviceable.

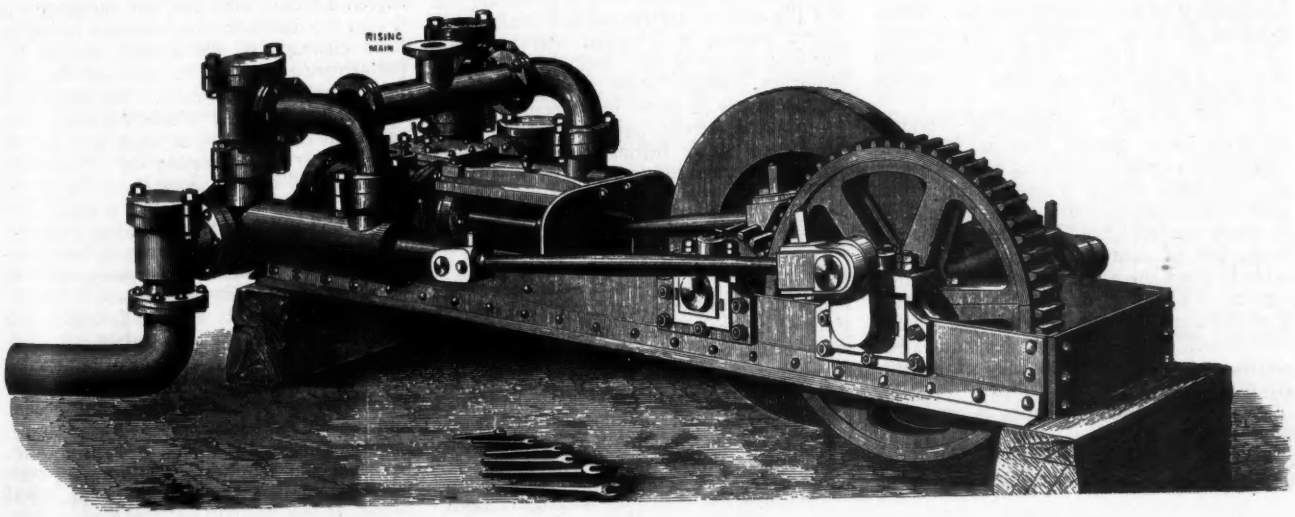
ENGRAVINGS OF 1872

The "Great Clock for the Cathedral of Beauvais" was the subject of an article published in our issue of April 26, 1872, from which this engraving (right) is reproduced. The clock was exhibited at Paris in 1867, and our article on it is a translation of a description circulated at the same time. When this engraving was made (in 1872) we were unable to say whether the clock had been erected in its place.

The description reads: "The first idea of this clock belongs exclusively to the Lord Bishop of Beauvais, who, justly proud of his beautiful cathedral, wished to endow it with a clock which, by its magnificent proportions and multiplied indications, should be an ornament worthy of that structure, that veritable *chef d'oeuvre* of past times. The bishop's thought had only to be expressed to be immediately acted upon. The case was executed according to the plans of R. P. Pierart, the pupil of the Rev. Father Martin, and the inheritor of his genius. It measures 39ft 4½in in height, 16ft 9½in in breadth, and 9ft 3½in in depth. It was conceived in the severe style of the Roman epoch, but in its decorations all the riches of Byzantine ornamentation have been exhausted. It is composed of two very distinct parts; the first is altogether architectural, the second especially symbolical. The base is a long square, and forms the ground plan of the case; and from this base rise solid pedestals which support four groups of five columns, on which rest the springings of a triple retreating archivolt, so that the case presents a porch on all its faces, having a depth of more than a metre, with an admirable perspective effect. On the side faces, the concentric archivolts show a triple semicircular arch, which, with its three columns, enshrines a bay of unique character." This part of the description ends by saying: "Nothing can be richer than the arches of the great arcades—roses, diamond points, saw teeth or damiers; all these decorations, forming a garland, cover the vertical planes of these covings. To finish his work the architect carried to the summit, on the extreme arris, a magnificent gallery of open sculpture work. Nothing can be more elegant than this crowning."



Below, there is reproduced, from our issue of March 15, 1872, an engraving illustrating a "pumping engine newly erected in one of the Strafford Main Collieries, near Barnsley, at a depth of 240 yards below the surface, by Mr. G. W. Hick, of Leeds." Our description of it reads: "the engine, which is intended to lift fifty gallons per minute, consists of a steam cylinder 9in diameter, 16in stroke, driving through a countershaft a pair of double-acting piston and ram pumps, the working barrels of which are 6in diameter, and lined with brass. The stroke of pumps is 12in. Although the water pressure due to the column is nearly 360 lb per square inch, the pistons of the pumps are not provided with any packing or leathers whatever, but are made of great length compared with their diameter, and they work comparatively frictionless and quite water-tight. The cylinder and pumps are bolted to two wrought iron frame plates ¾in thick, stiffened with angle iron, which carry shaft bearings somewhat resembling locomotive axle-boxes. The driving pinion is of steel, and the cranks for driving the pumps are forged solid with the countershaft, and at right angles with each other."



LITERATURE

Practical Solution of Torsional Vibration Problems : Volume I : Frequency Calculations. Third edition. By W. KER WILSON. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 105s.

THE title expresses very adequately the subject matter of this book. The previous editions have for long been classics in their field and this revised and enlarged edition is very welcome. One can be confident that a method of solution is to be found in this volume for the estimation of the frequencies of any practical torsional vibration problem. The general increase in speed of rotation of machines in recent years and the use of alloy steels with corresponding low hysteresis damping has led to many fatigue failures due to torsional resonance. An accurate calculation of all the resonant frequencies of the machine at the design stage is now essential.

The book is subdivided into twelve chapters. The addition of a historical review as an introduction is to be commended to authors of other subjects. It makes fascinating reading. The slow realisation of the basic approach to torsional vibration analysis may seem surprising to-day, when the determination of the natural frequency of a three-mass system is standard undergraduate work, but it was quite an advance in earlier times. This introduction is more than a merely historical review, a wealth of information is given in the references and the reader can easily trace the development of such aspects as the dynamic absorber.

Basic problems are treated very fully and are referred back to Newton's Second Law in nearly every case. An obsession for using differential equations has been avoided and the derivation of formulæ is so arranged as to appeal to the practising engineer. A very complete explanation of the motion of a simple system is given in Chapter I, leading to the introduction of simple harmonic motion. A thorough understanding of this is essential for any study in vibrations. It is, therefore, all the more a pity that there is a slight confusion about the name of the mass moment of inertia of a flywheel denoted by symbol *J*. This is called the polar moment of inertia or " flywheel effect " in the footnote on page 9, in which it is first introduced. This same quantity is referred to as the mass polar moment of inertia on page 14 and merely as the moment of inertia on page 15. The inclusion in each case of the word " Mass " is to be preferred so as to avoid confusion with the quantity, symbol *I*, which is called the polar moment of inertia of the cross section of a shaft. This latter quantity is really a second polar moment of area and it would be better to call it thus.

A very complete treatment of torsional vibration with geared systems is given. Much use is made of replacing actual systems by equivalent simple diagrams which can then be analysed by conventional techniques. A whole chapter (No. 11) is devoted to the derivation of equivalent shafts. A useful table is given on page 578 for the torsional rigidity of shafts of different cross sections. The effect of keyways and the like is also considered. The concept of equivalent inertia and masses is also fully developed. An extensive table of the radius of gyration of objects of different shapes is given on pages 547 to 551.

The inclusion of actual engineering units in the lists of symbols is to be commended and there should be no excuse for the reader omitting the gravitational constant from his calculations. There are many worked examples throughout the book. The illustrations are very clear and the whole presentation is excellent. There is an extensive, classified bibliography and both a name and a subject index. A further helpful feature is a classified list of worked examples. Volume I deals with the calculations of frequencies. Volume II is to deal with the calculation of amplitudes and stresses, and the analysis of experimental records. The publication of Volume II is certainly eagerly awaited.

Frequency Response. By R. OLDENBURGER. The Macmillan Company, New York, 10, South Audley Street, London, W.1. Price 52s. 6d.

THIS volume contains the papers presented at the A.S.M.E. Symposium on Frequency Response, 1953, together with ten other papers on automatic control, including two translated Russian papers. While it may have been the intention of the organisers of the symposium to confine the subject-matter to that covered by the title, the authors did not consider themselves bound by it and the papers range over most of the field of automatic control. It would perhaps have been better to abandon the title for the book, particularly as some time has elapsed since the symposium was held. Regarded as a general collection of papers on automatic control, this is of special interest as it is the first American book of its kind, the first published by a Society of Mechanical Engineers, and the first in English since the proceedings of the 1951 D.S.I.R. Conference on Automatic Control were published in 1952. One noteworthy feature is that, if any important new developments are under way across the water, they are as yet far from realisation ; these papers break less new ground than the 1951 Conference papers did, and not a few names appear in both indexes.

The present state of control theory is mainly one of consolidation, with only a few bold spirits venturing out into non-linear and statistical theories. However, even the " simple " linear theory requires a knowledge of mathematical methods such as complex-variable analysis, which have not long appeared in engineering courses. In the main, the authors have appreciated this and the result is a series of technically competent papers, well-written and relatively free from jargon of the " decibel and negative frequency " kind. While it is not possible in this review to enter into details of each contribution, certain papers can be selected because of their intrinsic merit or their relevance to engineering design.

The subject-matter is divided into sections, beginning with " Fundamentals." In this section a paper by R. H. Macmillan on " The Frequency-Response Method : a Brief Survey," is, despite the title, an excellent and comprehensive study of the present state of control theory, including pole-zero analysis and describing-function methods for non-linear systems. The next paper, by R. Oldenburger, on " Frequency-Response Data Presentation, Standards and Design Criteria," is the official A.S.M.E. attempt to standardise things which have so far retained, and will probably continue to exhibit, an obstinate variability. Another paper by Macmillan on hydraulic speed-control systems shows, more clearly than most application studies, the need for approximation and " linearising " before control theory can deal with an engineering problem. In the section on " Frequency-Response Aids," a useful, and probably unique, list of existing sine-wave generators is given by St. Clair *et al*, with details of their design and use. This country is represented by five examples. All the papers in the section on " Servo, Airplane and Power System Applications," concern some branch of engineering practice : H. A. Helm uses frequency response to design a mechanical servo for a contour-following lathe and gives a detailed dynamic analysis of pneumatic components ; A. C. Hall does the same for hydraulics. V. Oja studies the regulating properties of power stations by means of an elaborate frequency analysis, not, however, supported by direct experience. The paper by Smith and Triplett on experimental methods for evaluating aircraft response has the theme that the most convenient disturbance to apply is a pulse, the response to which has to be converted to the frequency domain ; the converse of the usual problem.

In the " Process Control " section the only novel concept is J. M. L. Janssen's " deviation ratio," though A. R. Aikman reports some frequency analyses of actual plant of a kind that still find difficulty in getting into print. On the laboratory scale, papers by Kramers and Alberda, and by Eyckman and Verhagen, on the dynamics of mixing and the response of thermometers, set a standard of accuracy in measuring and explaining experimental data. Of the various papers in the " Transient Response " section, little need be said except that considerable mathematical insight is needed to appreciate the points involved. Switching from the frequency to the time-domain and back again is an unfortunate necessity in control theory and has not yet been made painless, despite many attempts. The section on " Optimum Controls " contains an important paper by J. H. Westcott, " Synthesis of Optimum Feedback Systems Satisfying a Power Limitation." He examines a situation where a servo-motor has to follow an input with known statistical properties in such a way that the mean power required does not exceed a prescribed value, and shows how to design the feedback compensation round the fixed elements of the system so that the performance cannot be bettered by any other linear compensation. The method is extended to the case where a known delay can be tolerated between input and output.

No paper in the section on " Non-linear Techniques " can be singled out for special notice ; much of the work is a straightforward application of Kochenburger's describing-function method, which adapts frequency-response to systems containing isolated non-linearities by considering only the fundamental component of oscillation. This method has had considerable practical success where the presence or absence of self-excited oscillations is the main object of study, and sub-harmonic resonance does not occur ; and these papers contain much useful information on the design of systems with backlash and saturation. The three papers on " Sampling Controls " and " Statistical

Methods" add little to the material already available.

The format and style of the volume is of the high standard one expects from the American Society of Mechanical Engineers, and there is a notable absence of minor errors. The amount of work put in by Dr. Oldenburger and his associates can only be guessed at, but the result is commendable. The book will doubtless rank as a standard reference work on control engineering for some time to come.

Manganese Steel. Published for Hadfields, Ltd., Sheffield, by Oliver and Boyd, Tweeddale Court, Edinburgh, 1. Price 18s.

HADFIELD manganese steel has, since its discovery, occupied a unique position among the special steels. Many of its applications were foreseen in the first patent granted (1883, No. 200) and the claim there made ("By my employment of manganese I obtain an entirely new quality of steel hitherto totally unknown") received international recognitions. In the words of Dr. J. E. Stead, "Hadfield has surprised the whole metallurgical world with the results obtained. The material produced is one of the most marvellous ever brought before the public." So comprehensive were Hadfield's original investigations that the composition and heat treatment of the bulk of the manganese steel supplied have remained essentially unchanged since the early days of the discovery. The book, compiled by members of the staff of the Hadfield organisation, with a foreword by their Metallurgical and Research Director, Mr. E. W. Colbeck, not only records the history of the development of manganese steel but also gives full details of its composition, heat treatment, metallography (illustrated by numerous photomicrographs) and physical and mechanical properties, including those at both high and at low temperatures. The outstanding characteristic of resistance to wear and abrasion, on which so many of the applications of the steel depend, is discussed in detail. There are chapters on the welding and hard-facing of manganese steel, with references to recent improvements in technique, and there is an extensive bibliography. The book contains all available data of interest to users of manganese steel, and in sponsoring its publication, Messrs. Hadfields, Ltd., have rendered a valuable service to engineers and metallurgists.

Handbook of Fastening and Jointing Metal Parts. By V. H. LAUGHNER and A. D. HARGAN. McGraw-Hill Publishing Company, Ltd., 95, Farringdon Street, London, E.C.4. Price 112s. 6d.

THERE are innumerable ways of jointing metal parts, but it is not until a reader sees a 600-page book of this kind that the wide choice of methods available to the designer is fully appreciated. The first part of the book is divided into sections covering in detail screw threads and pipe threads; screws, bolts and nuts; lock nuts, washers and retaining rings; practical considerations in the design of screw fastenings; riveting, setting and staking; welding with pressure; gas, arc and thermit welding; brazing and soldering; adhesives and adhesive bonded joints; collars, couplings and clutches; keys, splines and interference fits; and other assembly methods, integral fastenings and special fasteners. In the second part of the book some 200 pages of diagrams show in a simple, graphic way the methods by which special problems in joining and fastening parts have been met. Although based mainly on American practice and standards, this handbook should be a useful and interesting work of reference to all industrial designers.

The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys: III.—The Control of Quality in Heat-Treatment and Final Operations. The Institute of Metals, 4, Grosvenor Gardens, London, S.W.1. Price 15s.

THIS Monograph (No. 17 in the Institute of Metals Monograph and Report Series) contains the report of a symposium held in London in March, 1955, and is the third of its kind, previous reports having dealt with the control of quality in casting and in working operations, respectively. The six papers presented and the ensuing discussion deal mainly with copper alloys, nickel alloys and aluminium alloys, and are concerned with the heat-treatment and finishing operations, inspection and testing of wrought products of these alloys. In the course of the description of the measures taken to ensure a uniformly high quality of the products, many defects which may be encountered are described and illustrated. Few of these, however, would escape detection before the material leaves the works, and failures in service are much more frequently due to faults in design and fabrication than in the metal itself. It is a satisfaction to users of metals to be assured of the extent to which works inspection and control of all manufacturing operations have been developed and extended in the non-ferrous metals industry.

Aircraft Gas Turbines. By C. W. SMITH. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 70s.

THIS book, one of many recent additions to the literature of this now fertile field of thermodynamics, rapidly distinguishes itself by introducing a term X, the isentropic factor, defined as

$$\frac{\gamma-1}{r^{\gamma}}-1,$$

and this is used throughout the subsequent theory to simplify the presentation. A table of values of X to five significant figures is appended. Thus, the book is intended rather for the advanced student than for an *ab initio* study of the subject: the tables of symbols used in the text occupy seven pages of small type. This impression is confirmed by finding a pleasing explanation of the principles of supersonic axial compressors, and a swift and trenchant assault upon the calculation of the stability of any control system. While the greatest emphasis is laid on basic theory, the practical operation of the engine is kept constantly in mind, and such subjects as thrust reversing and gyroscopic precession in manœuvres are discussed, while current problems of the United States are clearly in the author's mind when he observes: "Traffic control problems should be less serious with the propjet than with the turbo-jet."

Diesel and High Compression Gas Engines. By EDGAR J. KATES, A.B., M.E. The Technical Press, Ltd., 1, Justice Walk, Lawrence Street, London, S.W.3. Price 44s.

IN this book the author sets out to deal with the subject of diesel engines in plain and simple language, which is understandable by the non-technical as well as the technical reader. The book is concerned with fundamentals and the subject matter is arranged in logical order, beginning with notes on what a diesel engine is and its basic construction, followed by an explanation of the terms of physics and engineering and the relationship between heat and combustion. Chapters are devoted to fuels, fuel consumption, power and engine performance, followed by others describing the mechanical parts of an engine, valve gear and scavenging systems and engine governors. Considerable attention is paid to fuel injection systems and to the burning of fuel, and to lubricating oils and lubricating systems, while the broad grouping and classification of engines is examined mainly by illustrations. How the various auxiliary systems, such as lubricating, cooling, exhaust air intake and starting, essential to the running of a diesel engine function is explained and followed by general advice upon operation and maintenance. A special chapter deals with high compression gas-burning engines.

Mechanical Engineering Practice. Fifth edition. By CHARLES F. SHOOP and GEORGE L. TUVE. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 52s. 6d.

THE fifth edition of this laboratory reference textbook includes a chapter on "Characteristics of Automatic Controls," which, by means of simple experiments with water running into tanks and various valves, guides the student to a clear understanding of the fundamentals of process controls. The exact nature of the experiments will, of course, depend on the equipment used in the individual college, so that the later experiments are specified only in general terms. The mathematics is kept to a minimum: the co-author, L. G. Seigel, remarks; "Time constants can be evaluated from an overall analysis by frequency-response methods," but does not discuss the matter further. In other chapters also the use of modern equipment, such as chassis dynamometers and exhaust gas analysers, is anticipated.

Flow Measurement by the Differential-Pressure Method. George Kent, Ltd., Luton, Bedfordshire. Price 10s.

THE main subject of this book is the simple square-edged orifice. Orifice tables are given for liquids and gases in pipes from 2in to 12in in diameter for varying orifice sizes, both in British and metric units. An interesting section deals with the effect on accuracy of departures from the conditions assumed in the flow formulæ, such as uniform approaching flow, and is followed by a strictly practical treatment of the problems of pressure pipes for fluids, vapour and dirty liquids. The handling of flow records and the application of square-root planimeters and decimal-flow charts are discussed, together with alternative devices to generate pressure differentials, such as the Venturi tube, whose origin is described in the introduction. Kent products with applications to flow measurement are described in the last quarter of the text, and include orifices for steam up to 1500 lb per square inch and 900 deg. Fah., Venturi and Dall tubes, automatic recorders and controllers, and varied pressure-sensing devices.

Books Received

Merchant Ships: World Built. Published by Adlard Coles, Ltd., 7, Brunswick Place, Southampton. Price 30s.

Metal Industry Handbook and Directory, 1956. Published by Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 15s.

Development of Power Cables. By P. V. Hunter and J. Temple Hazell. George Newnes, Ltd., Technical Books Department, Tower House, Southampton Street, Strand, W.C.2. Price 25s.

Energy from the Sea

By J. H. M. SYKES, ASSOC.I.E.E.

A study-tour and conference on energy from the sea was held recently by the Société Hydrotechnique de France. The site of the tidal power barrage on the Rance was visited and delegates were able to inspect the large tidal model which has been in use at Saint-Servan, near St. Malo, since March 5, 1955. This model has been used for tests concerning constructional work as well as the theoretical design of the Rance tidal power scheme, which is designed to have a peak capacity of 342MW from thirty-eight 9000kW generating sets, with an annual output of over 800 million kWh per annum.

AMONG the few countries engaged, during recent years, in research into the possibility of generating substantial amounts of electrical power from the tides, France has been pre-eminent, and reports have been received from time to time to the effect that at least one of the tidal power schemes proposed for the Brittany coast had reached the stage where construction work might be expected to begin. This stage has now been reached in the case of the Rance scheme, and the writer was particularly interested to have the opportunity, during a recent visit to St. Malo, to see construction work actually in progress on what will be the world's first tidal power plant, when it is completed in 1960.

It was decided by the Société Hydrotechnique de France to institute a week's study tour and conference on the whole subject of energy from the sea, and it was in conjunction with this conference that the visit was paid to the site of the tidal power barrage on the Rance. The members of the delegation, which included some 200 engineers from many parts of the world, had travelled from Paris with the main object of inspecting the extensive tidal power model which has been in operation at Saint-Servan, near St. Malo, since March 5, 1955.

This model was constructed in order that those concerned with the finalisation of the plans for the Rance scheme should have available on site means for carrying out every kind of model test, not only those relating to the theoretical design of the tidal power scheme as a whole, but also tests concerned with the actual constructional work.

The model itself is housed under a low roof and the 31 square kilometres of the Rance estuary is reproduced to a scale of 1/150, the model thus taking up a space 17·5m wide and 150m long; the building, therefore, covers approximately one acre of ground. The floor of concrete has raised portions to indicate the banks of the river, and the tidal flow is produced at the seaward end by a pumping arrangement controlled by servo-mechanisms which are coupled to a specially developed tidal model which has been the subject of much study over many years by the Laboratoire National d'Hydraulique. In this model, a band of paper has painted on it, in Indian ink, a diagram representing the tidal rise and fall it is desired to reproduce in the model. The chart, as it passes over rollers at a predetermined speed, is scanned by a beam of light which is reflected on to a photo-electric cell. Situated at various points on the model itself are water depth indicators of the kind in which a vibrating point is used, and these indicators feed back their impulses into the tidal model master unit so that the pumping device is ultimately controlled in such a way that the desired tidal cycle in the model of the estuary is perfectly reproduced. In other words, when the originating chart gives an impulse which should lead ultimately to a certain depth of water at a certain point on the chart, the pumping is controlled so that this depth of water at that instant is actually achieved. Various materials can be introduced into the currents of water to simulate gravel and sand, these taking the form of carbon and plastics materials scaled down so that the density of the material and the size of the particles corresponds to the actual gravel found in the estuary itself.

The time scale is the same as the dimension scale, and thus, with a tide of an average duration of twelve hours twenty-five minutes the complete tidal cycle is reproduced on the model in exactly one hour.

One of the more interesting studies seen during the recent inspection of this model was that which related to the final closing of the dam after it has been built. The solution for the closing problem which has been provisionally agreed is to use conveyor belts running from either bank to the sides

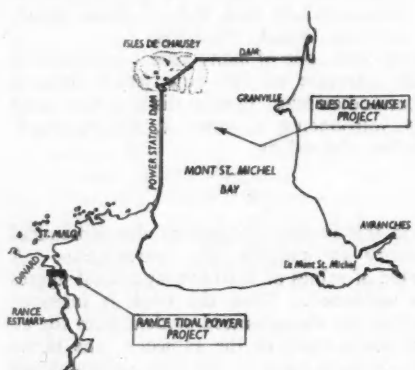


Fig. 1—Tidal power projects of the Rance and Isles de Chausey

of the breach and then to feed in the aggregate and other materials at as rapid a rate as possible during suitable phases of the tide. This work has been simulated on the model by the use of vibrating conveyor belts on either side of the proposed dam structure with an adjustable output varying between zero and 50g per minute, which is equivalent, at full scale, to zero to 14,000 cubic metres of material per day. In this way the contractors who have undertaken the civil engineering work have ample opportunity to carry out exhaustive studies on the problems of the final stages of closing the dam.

The most important feature of the whole Rance scheme, and one which has not so far been made widely known, is the fact that the prolonged studies undertaken into the utilisation of tidal power by Electricité de France have resulted in a much greater utilisation period for the tidal energy than has ever been considered feasible before. This advance has been mainly due to the evolution of the bulb generating unit, in which a horizontal-shaft generator is completely enclosed and situated within the dam itself, being coupled to a runner of the Kaplan type, with blades adjustable through 180 deg. This form of machine, which has already been used in France in certain run-of-river schemes* (some of which were visited at the conclusion of the conference) has been found to lend itself particularly well to tidal power projects. It can be used both for pumping and for power generation in both directions, and it can also take the place of a sluice gate or valve.

Previous tidal projects have envisaged operation either as a single-effect scheme, using the tide flowing only one way through the dam, or a double-effect scheme sometimes with complicated sluice way arrangements. The bulb unit installed in the single dam envisaged for the Rance scheme enables single-effect or double-effect cycles to be used at will, and the real significance of this project is that, by "borrowing" power from thermal stations during off-peak periods the system operator can almost obtain tidal power at whatever period of the day he wishes, irrespective of the actual state of the tide.

The modes of operation which are carried out are as follows, starting from high tide. The turbines may be used as pumps if energy is available, i.e. if it is an off-peak period, to fill the basin to a higher level than the top tidal mark. Next, as the tide falls away on the outside of the dam, the turbines can be used to generate power; when the head has fallen too low for power generation the turbine blades are oriented by feathering so that they act as valves to allow more water to flow through to the seaward side. Then the turbines once more become pumps and empty the basin still lower. The tide will by now have started to rise on the seaward side, and as the water in the basin is artificially low, power generation can take place, this time with a higher level on the seaward side than in the basin; and once this level becomes too low for generation the turbines are again feathered so that simple valve action takes place up to full tide again. The cycle, with variations of timing to suit the available energy from the network for pumping and the energy required from the tidal scheme, is repeated with each of the two tides in the day, and so on continuously. In this way the Rance scheme, working in conjunction with the extensive hydro and thermal power plant network of the remainder of France, will be able to provide over 800 million kWh per annum, and its peak capacity of 342MW, made up of thirty-eight generating units of 9000kW each, will be available, it is claimed, at almost any time for a limited period, in accordance with load requirements.

Work has just started on the dam, which is to be situated about 2·17 miles south of the port of St. Malo (Fig. 1), and the basin it will enclose will have an area of about 7·72 square miles. The dam will be 2329ft long and 157·4ft wide and will be hollow (Fig. 2) to contain the generating sets and other ancillary equipment. The height of the crest of the dam above the highest recorded tide level will be approximately 5ft. On the west side of the dam structure there will be a navigation lock.

This scheme, as mentioned above, is planned for completion by 1960, and it is intended that it should serve, to some extent, as a pilot scheme for the very large project also being exhaustively studied by Electricité de France, and which is concerned with the erection of a dam of a total length

*See THE ENGINEER, October 29, 1954, page 595

of 23·4 miles enclosing the whole of the area of the bay of Mont Saint Michel (Fig. 1). This basin would have a superficial area of between 270 and 308 square miles, and the dam would run due north from the Pointe du Grouin to the archipelago of islands known as the Iles de Chausey, and from thence almost due west to join the mainland again a little north of the town of Granville, at Cotentin. The north-south portion, from the Pointe du Grouin to the Iles de Chausey, would be the power dam and would be made up of 400 caissons, including some 1200 bulb generating units, each of between 7000kVA and 10,000kVA. The total output capacity would be 8,000,000kW to 10,000,000kW, and the energy producible per annum would reach 25,000 million kWh, which is about 50 per cent of the present French consumption of electrical energy. This gigantic project would require fifteen years to complete, and at the conference it was not possible to gather any firm indication as to whether or not the Iles de Chausey scheme is likely to materialise.

The technical visit to St. Malo included a journey to the Iles de Chausey to inspect the site of the proposed dam for this major project, as well as visits to the tidal model and a journey down the Rance past the site of the scheme, on which work has now commenced.

The members then returned to Paris to spend three days in discussion on the numerous papers presented by French engineers, not only on problems of tidal power, but also on every other aspect of energy from the sea. These included a series of papers on the mechanical energy of the waves, and exhaustive details of investigations made on the constitution, propagation and methods of prediction of trains of waves in the ocean were set out in these valuable documents. A further section dealt with the possibility of using the energy of the waves for power generation. Here two methods were proposed. Mr. J. Valembois, of the Research Department of the Laboratoire National d'Hydraulique of Electricité de France, gave a paper in which it was suggested that there was a possibility of using resonating devices for utilising wave power, and two solutions were proposed. In the first solution the resonating device takes the form of a cone-shaped tube, open at both ends and sunk in the water of the sea to about half its height. The waves cause the water level outside the cone to fluctuate in a periodic rhythm, and if the natural frequency of the cone is correctly chosen the oscillation of the water within the cone (the smaller end being upwards) will be several times greater than that of the water outside. It will be necessary to have several cones designed for different frequencies if the wave energy is to be utilised under differing conditions. A second proposal, but one which was rejected by the author of the paper, was to have an adjustable cone which could be made suitable for any wave frequency. This adjustable cone would have the disadvantage of requiring movable equipment, which would be subjected to the full force of storms, and thus would not be practicable on a large scale. It was felt that there might be some possibility of development along the first of these lines. The second scheme, produced by Mr. R. Dhaille, proposed the use of dihedral-shaped blocks across the opening of an estuary, and by suitable design of the contours it was shown that the waves would enter the narrowing openings and would build up higher water levels behind the dam, in spite of the existence of the openings, this higher water level being utilised by normal hydro-electric methods.

Both these suggestions were fully discussed, and it was felt that under certain circumstances practical use might be made of either of them, but that at the present time the economic efficiency would not be high enough to warrant a large-scale project.

An interesting section of the conference was that which related to the electro-magnetic energy of the oceans, discussed in a paper by Professor Y. Le Grand, of the Oceanographic Institute of Paris. The paper gave a number of reasons for the appearance of electrical currents in the water of the sea. They included a variation in ionisation level and temperature, thus setting up electro-chemical batteries, although the e.m.f.'s so caused are very small; the coast line materials may, under certain circumstances, cause electro-chemical reactions to be set up as a result of their contact with sea-water; the movement of masses of water across the magnetic field of the earth gives rise to induced voltages and consequently currents; and the variations of the vertical component of the earth's magnetic field also cause induced currents to be set up.

The author described a considerable number of measurements made of electromotive forces set up between different parts of the surface of the sea. Although it was not proposed that these effects should be used for power generation, nevertheless, there was active interest in obtaining more exact data in this field since it was hoped eventually to provide valuable means for measuring the displacement of large bodies of water, such as tides and currents, with an accuracy and simplicity not hitherto attainable.

The utilisation of the temperature difference between the top layers of tropical seas and the cold water at the bottom of the ocean is a matter which has engaged the attention of French engineers for many years, and large-scale experiments have been carried out, at Abidjan, on the Ivory Coast of Africa, particularly in regard to the pipework needed for pumping cold water from great depths, and for gathering surface water under conditions of disturbed weather conditions. A report to the conference by Mr. C. Beau showed that the mechanical problems associated with the Abidjan project have now been solved, and it included some interesting photographs of the welding operations taking place under 49ft of water on the bottom pipeline, this being 5·9ft in diameter. The first generating unit, of 3500kW capacity, is soon to be installed. Briefly, this kind of plant utilises the warm water which is transformed into vapour by being admitted to an upper chamber in which a high degree of vacuum is obtained. The vapour then passes through the blades of a turbine arranged on a vertical shaft, with the alternator above. Below, this vapour meets cold water pumped from the bottom of the sea and is condensed, creating a vacuum which sucks further vapour through the turbine blades, resulting in the alternator being driven. In addition, this scheme provides large quantities of soft water, and salts of commercial value from the evaporation of the sea-water. It is expected that in several years' time sufficient experience will have been gained with this first plant (which has been under consideration for at least seven years) to design a larger unit, which may be the prototype for large-scale application of this interesting principle in many tropical situations.

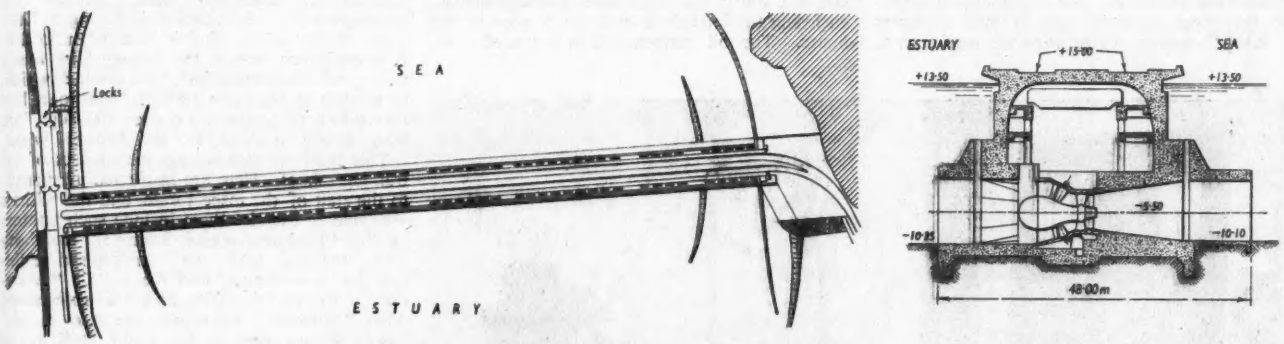


Fig. 2—Plan and cross section of the Rance tidal power dam

French engineers have always been noted for pioneering thought on large-scale problems concerned with natural forces; and this tendency was illustrated once again at the conference by a fascinating paper which could almost have been found in the pages of a science fiction magazine. It was by Mr. C. Rougeron, and it dealt with the possibility of warming the southern part of the North Sea with the aid of the Gulf Stream, and the climatic consequences which might be expected to follow. Briefly, it proposed the building either of a complete dam across the Straits of Dover (with suitable locks for shipping, and tidal power generators) or two jetties out from England and France to give the same effect on a partial basis in regard to the control of the flow of water through the Straits. The author's argument showed that if it was possible to allow the relatively warm water to flow from the Channel into the North Sea, without allowing for its return, the average temperature of the whole area of the southern North Sea might well be raised by 1 deg. Cent. in summer and 3 deg. Cent. in winter, and the autumn season in the neighbouring lands would be prolonged. The author showed that the temperature of the North Sea near the Dutch coast fell to 3 deg. Cent. in an average winter, while at the same time the temperature was 12 deg. Cent. at the

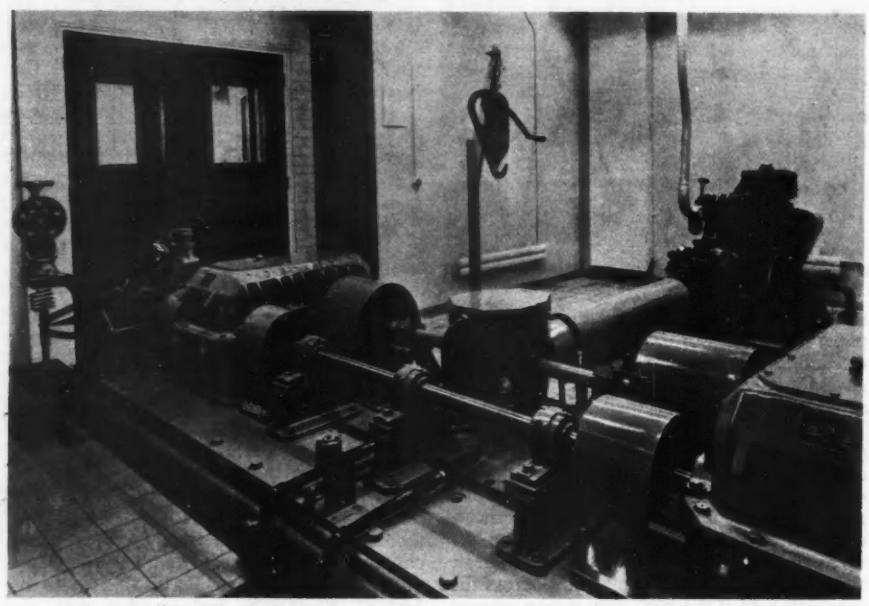
entrance to the English Channel. This condition, he claimed, was due to the fact that the water in the southern North Sea was seldom changed by the action of currents and tides, because the water flowing down the east coast of England met the water flowing up the Channel, and the result was partial stagnation. The barrage to control the flow would mean that this state of stagnation could be materially affected, thus increasing the temperature of this area of sea by warmer water from the Atlantic.

After the formal sessions, visits were paid to the Laboratoire National d'Hydraulique at Chatou, and the Laboratoire Central d'Hydraulique de France at Maisons-Alfort, and a second study tour for some members of the conference took place to see the prototypes of the bulb type units in use at Argentat and Cambeyrac.

Oil Test Laboratory

LAST week, the Inspectorate of Fighting Vehicles opened an oil test laboratory at its test house at Pinehurst, Farnborough, Hants. The laboratory is primarily concerned with the mechanical testing of engine and gear oils for conformity with agreed standards, but is also intended to develop new or improved test methods.

The equipment for engine oil testing includes two single-cylinder Caterpillar diesel engines, sited in the same cell and sharing a common electric motor for running-in and starting: these perform the 480 hour runs for the "L.1" test for detergent oils to the United States Mil-0-2104 standard. As a preliminary screen to this most expensive test, a pair of Petter "A.V.1" engines driving fans are used; these is shown in the accompanying illustration. A Perkins "P.4" and the second gear of the five-speed box used in the Rootes 1-ton combat vehicle drive the pinion at 278 r.p.m. 20-to-1 speed increasing gears at each end of the axle are coupled together to drive a dynamometer; the dynamometer consumption is corrected for losses in these gears, the power throughput of the axle under test being 15½ h.p. The oil temperature in the differential housing is sensed continuously, and when it reaches 250 deg. Fah., the casing is sprayed with water at the command of an automatic control unit, which shuts off the water again when the temperature falls to 200 deg. Fah.; the water pipes and the shroud enclosing the final drive unit can be seen in the figure. The oil temperature is recorded continuously throughout each run, which lasts sixty hours.



Rig for testing a rear axle at high torque in the Inspectorate of Fighting Vehicles test house. The equipment to spray water on the differential housing can be seen

small diesels also carry out quality control checks. One test bed is equipped to carry out the Chevrolet "L.4" test of oxidation and corrosion qualities, and two have Petter "W.1" engines to perform tests correlating with the "L.4"; however, it is believed that the single-cylinder petrol engines also give useful information regarding the detergency of the oil. All the test cells feature remote controls, automatic in many cases, so that, except when necessary to use mercury-in-glass thermometers or examine the engine for oil leaks or other faults, personnel remain outside the cells. The engines are mounted on isolated foundations, and in the case of the Caterpillar engines these consist of concrete blocks over 10 tons in weight resting on rubber mats.

Gear oils are subjected to extreme pressure tests in the hypoid axle of the Standard "Vanguard." The routine of high-torque, low-speed tests with this axle to satisfy specification Mil-2105 was developed in this country by Anglamol, Ltd., and the equipment installed to perform it

High-speed oil tests are performed on a complete car; for each test the car is ten times accelerated in top gear from 25 m.p.h. to 70 m.p.h., the overdrive being engaged at 60 m.p.h., the throttle is then closed completely, and the clutch is disengaged while the speed drops from 45 m.p.h. to 25 m.p.h.

Although the laboratory was only completed in April this year, visitors were shown numerous examples of its work. Particularly interesting were displays of tested crown wheel and pinion sets. Where the effectiveness of additives is being assessed, gears which have been given no surface treatment after grinding are used, in order to impose a severe test upon the oils. Such a gear was displayed which, after five and a quarter minutes running at high torque with S.A.E.90 hypoid gear oil, had failed with severe abrasion of the mating faces; a gear that had been subjected to the "Parco-Lubrizing" process completed a sixty hour run on the same straight oil. A convincing illustration of the value of the road running tests is given by the facts that gears like these two lasted ten and an easy thirty tests, respectively, at high speed, while gears that had been phosphated, or phosphated and then molybdenised, successfully endured sixty tests. The most successful surface treatment tested to date used a sulphur compound; molybdenum bisulphide alone effected no improvement.

A striking outcome of the high-torque results, upon which we were offered no comment, is that the use of extreme pressure additives, or of successful surface treatments, is accompanied by a more frequent call for cooling water, suggesting that the reduced wear on the gears is associated with a reduced mechanical efficiency.

The inspectorate is responsible for all vehicles acquired by H.M. Government, whether for use by the Armed Forces or other departments such as the Post Office, and consequently a highly adaptable inspection service must be provided. Adjacent to the laboratory is a vehicle inspection section which acts as a monitor on the inspectorate staffs at manufacturers or on firms' approved inspectors. Sample vehicles are sent to Pinehurst, dismantled, and critically examined; during 1954 and 1955, an average of twenty-three faults were found on each vehicle, varying from a cracked cylinder block to blockage of fuel tank breather pipes by paint. This section also conducts trials, such as running vehicles submerged for fifteen minutes, and investigations of deficiencies, including a 1-ton water tanker whose chassis bent when loaded. A conspicuous item in the display here was a worm and wheel drive for a 10-ton winch which, in process of winching 270ft at 7 tons load, had reached an oil temperature over 400 deg. Fah. with severe damage to the bronze wheel.

This building also housed the vehicles of the training school. Here are instructed all recruits to the staff of the inspectorate, and the vehicles available to exercise them include such tractors as the Meadows-engined Scammell, six-wheel-drive Leyland with the standardised eight-cylinder Rolls-Royce, and the A.E.C. "Matador." Combat vehicles and the six-wheeled Alvis "Saracen" scout car are also in use. About 25 per cent of the entire staff attend courses here each year, and students from other departments and private firms also attend.

It is the function of the test house to provide gauges and mensuration facilities for the inspectorate, and for this purpose it has extraordinarily complete tool-room facilities. The machine and fitting shops are able to construct inspection equipment up to a mobile radiography set, and there is a plating shop which, besides undertaking electro-plating, has a "Dalic" plant which can apply thin metal plate without the lengthy preparation normal with bath plating.

The temperature controlled bay houses a range of internal and external grinders and a jig borer, and there is an optical projector offering magnifications up to 100 while allowing work to be done on the subject by hand. The master profiles here are prepared in two colours, the junction between them defining a line of no thickness; the technique of preparation is simple, one dye being applied, the surface covered with transparent adhesive tape, and the form marked out with a knife. The tape on one side of the required line is then removed, the second dye sprayed on, and the remainder of the tape detached when it is dry. The equipment for inspecting completed gauges includes a three-dimensional surface table and another of granite.

The standards room, which is automatically maintained at 68±1 deg. Fah., houses an interferometer able to measure slip gauges up to 2in long with a cadmium light source and 4in long with mercury light. To check slip gauges against masters an Eden-Rolt comparator calibrated to 1×10^{-6}in is used, while for gauges up to 50in long an accuracy of 0·000005in is offered by a Matrix spirit-level comparator. A Coventry instrument affords thread pitch measurement to ±0·00001in.

The metrological plant is supported by equipment for physical, metallurgical, and electrical test work. The test house staff number about 200, and the oil test laboratory is manned twenty-four hours a day.

Self-Contained Turbo-Chargers

THE series of exhaust turbine-driven superchargers, which have recently been introduced by the Brush Electrical Engineering Company, Ltd., Loughborough, are intended to be supplied to diesel engine builders as self-contained auxiliaries, needing only to be ducted to the inlet and exhaust ports. The design is such that they can be assembled in manifold different configurations.

The general arrangement of the turbo-charger can be seen in Fig. 1. In this illustration an air intake with an annular air filter of three-ply oil-wetted felt is shown : an alternative fitting is a casting connecting to a duct leading, if desired, to a source of cool air. The walls of the intake are lined with a foamed plastic material, attached with adhesive, which serves to reduce the emission of noise. A set of simple pre-whirl blades leads to the single stage unshrouded centrifugal impeller, which has nineteen vanes and is machined from a light alloy drop forging. The diffuser also is machined from the solid, and leads into a volute built up from circular castings ; all the structural elements at this, the cool, end of the unit are light alloy.

On to the rear cover of the compressor is attached the exhaust casing of the turbine. This is a steel casting, and, of course, works through a large temperature range, so that the two castings are located by a set of four radially disposed pins which lie in semi-circular grooves in each component. They are clamped together by a series of spring plates loaded by bolts and nuts. The temperature gradient being small, the turbine inlet casing is attached rigidly to the exhaust collector, but the turbine bearing housing is again located kinematically. The inlet casing carries the nozzles ; these are formed of blades of F.C.B. (T) cast into iron rings at their roots and tips, the outer ring being divided into four by saw cuts.

The single-stage axial turbine consists of an austenitic forging with blades of the same material, held on by welding. The turbine blades may be either precision forged or milled from bar. The disc is secured to a welded-up steel shaft of which the centre section is hollow. Adjacent to the turbine disc is a labyrinth ring pressed on to the shaft, and beyond it the journal of a plain bearing is hardened and ground. At the other end of the shaft the impeller is a press fit retained by a nut, but a driving pin is provided. A labyrinth seals the back face of the compressor near to its outer edge, in order that end thrust shall be a minimum ; residual thrust is accepted by a plain two-sided thrust bearing assembled on the shaft beyond another labyrinth. Overhanging the second journal bearing is a worm gear which drives a bronze wheel on a vertical shaft leading to the pressure and scavenge oil pumps. These pumps are at the bottom of the integral oil tank ; the scavenge pump empties the turbine bearing housing and allows the unit to be run indefinitely at an inclination of 15 deg. and momentarily at 22½ deg. The pressure pump passes oil to a Vokes full-flow fabric filter with a relief

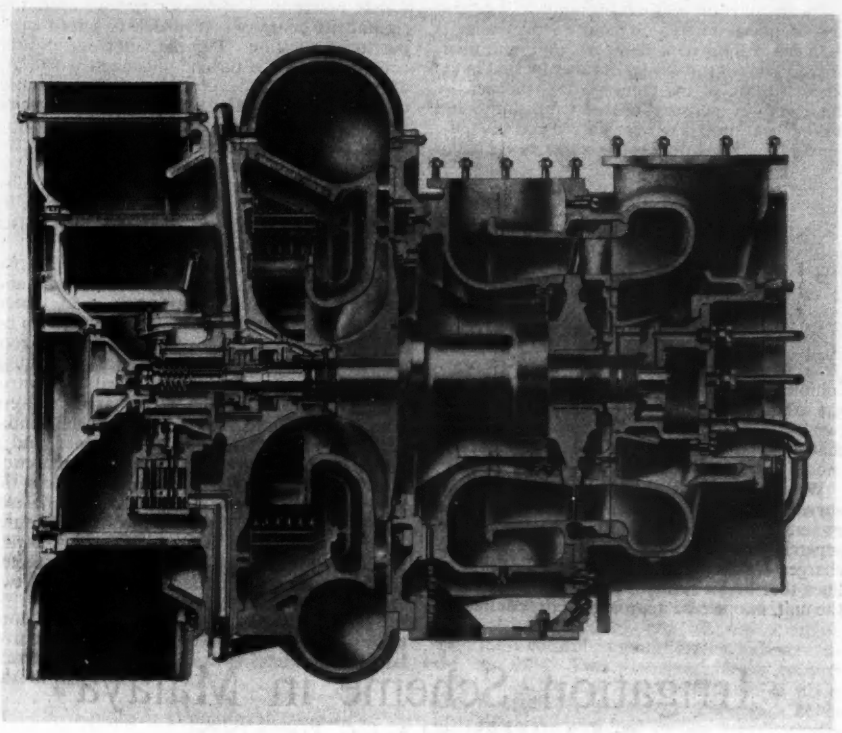


Fig. 1—Section through turbo-charger, showing oil cooler in air intake

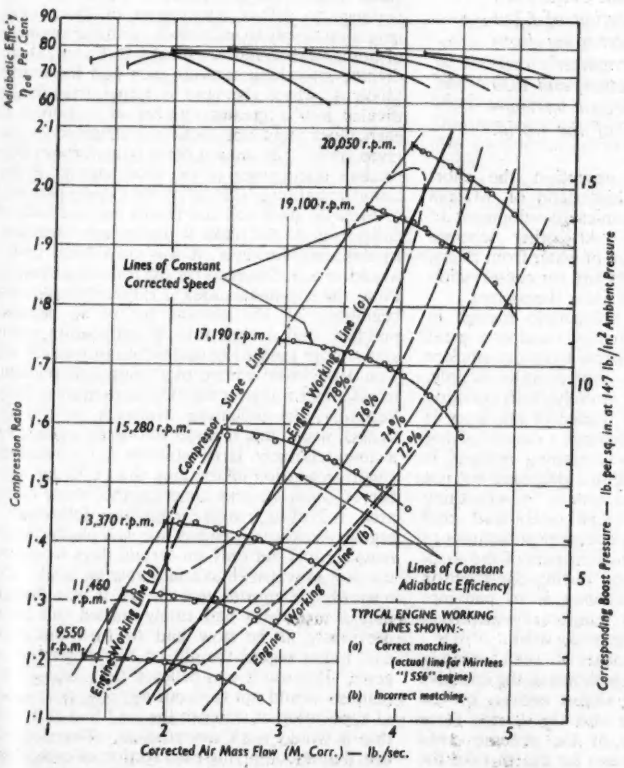


Fig. 2—"HB 20" compressor characteristics showing correct and incorrect engine matching

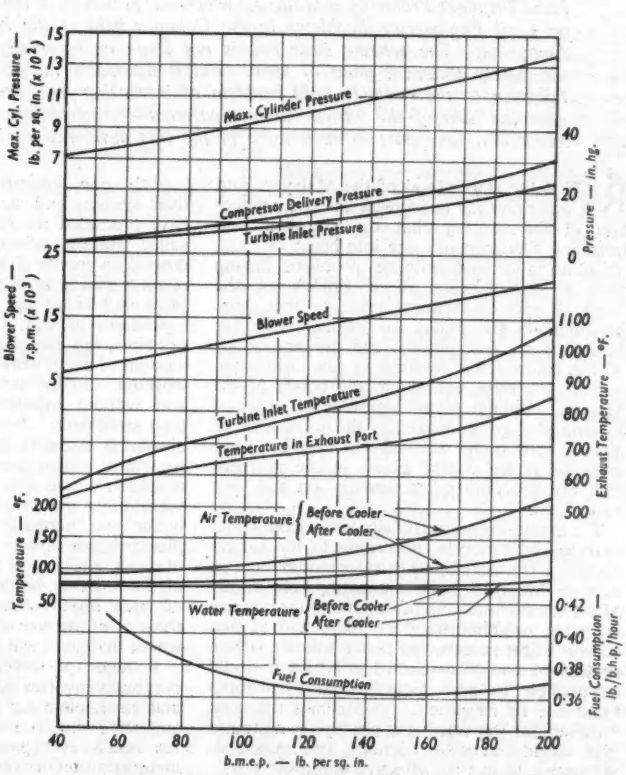

Max. Cyl. Pressure — lb. per sq. in. (x 10²)
Compressor Delivery Pressure
Turbine Inlet Pressure
Pressure in. hg.
Blower Speed — r.p.m. (x 10³)
Blower Speed
Turbine Inlet Temperature
Temperature in Exhaust Port
Exhaust Temperature — °F.
Temperature — °F.
Air Temperature { Before Cooler / After Cooler
Water Temperature { Before Cooler / After Cooler
Fuel Consumption
Fuel Consumption lb./b.h.p./hour
b.m.e.p. — lb. per sq. in.
1186 b.h.p. at 200lb. per sq. in., b.m.e.p.

Fig. 3—Mirrlees "J SS 6" engine at 1000 r.p.m. with "HB 20" turbo-charger and after-cooler

valve to by-pass it if it becomes clogged, and thence to the journal and thrust bearings. The oil and the diesel engine charge air are kept separate by pressurising the shaft labyrinths with air tapped from the volute casing. The air that passes through these either re-enters the compressor, cools the upstream face of the turbine disc, or passes into the lubricating oil system. That which leaves through the oil tank breather is passed over a set of fins on the pump shaft that centrifuge out any oil droplets. A turbine oil or that used in the diesel may be used, and it should last 1000 hours' running.

The use of plain bearings presupposes a certain loss of power in friction, and an oil cooler is included in the circuit between pump and filter. This consists of three rings of tubes located in the intake casting of the compressor; the penalty this incurs in increased charge temperature and turbine heat drop is not considered excessive, the temperature rise through the cooler being about 4 deg. Fah.

The unit is at present made in two sizes, and is matched to the requirements of different engines by varying the compressor diffuser throat area, the turbine nozzle throat area and the height of the turbine blades. Final adjustment to individual engines is effected on the nozzle area. Depending on the geometry of the engine, the four casings for inlet and outlet of air and gas can each be assembled at twelve different angles, and the mounting foot for the complete unit attached at seven positions to the gas exhaust collector. The gas intake can have two, three or four entries, it being recommended that exhaust ports consecutive in firing order should not supply the same duct.

We reproduce as Figs. 2 and 3 the performance curves for one of the larger turbo-chargers at present in production, and for an engine with the supercharger and an aftercooler. The turbo-charger characteristics show also the working lines that might result from a failure to match the unit, in one case approaching the compressor surge line and in the other running well away from peak compressor efficiency.

On the performance curves for the blower engine it should perhaps be observed that the curve of exhaust port temperature represents a time average of temperature downstream from one exhaust valve; it is not, therefore, strictly related to the temperature of the gas leaving the cylinder, and is included principally because it is commonly recorded in diesel operation.

At the manufacturer's works facilities for development and production test running have been provided. A 250 h.p. electric motor can supply power for compressor testing, while this rig and its compressor can deliver air to carry out turbine testing. For the latter purpose the compressor on the turbine under test would act as a brake, but by coupling the compressor through a combustion chamber to the turbine the rig becomes self-driving once run up by a small electric motor. When we visited the development test rigs, information on the temperature distribution over the turbine disc was being sought by setting small pellets in its surface and assessing their hardness after running.

The production test building can run two units as gas turbines, combustion chambers and fuel systems for the purpose having been developed by the makers. Each is started up by supplying the combustion chamber with air from a 12in centrifugal compressor driven through step-up gears by a 3622 c.c. Ford V-8 petrol engine. A valve in the supercharger delivery duct is kept closed until the pressure differential across it disappears, when it is opened and a valve in the starting compressor connection closed; only one rig can be connected to the starting plant at one time. Extensive instrumentation, particularly for temperature measurement, is provided in the control cell. Allowing time for a unit to cool after testing, it is expected that four sets will be tested each day on the two rigs when production demands it.

Irrigation Scheme in Malaya

By R. L. AKERS* and A. I. G. ROBERTSON†

The following description is abstracted from a paper entitled "Irrigation and Land Drainage Problems in Malaya," which was presented at the recent Conference on Civil Engineering Problems in the Colonies held at the Institution of Civil Engineers. The scheme described is not large or especially interesting from the purely technical point of view. But it illustrates the civil engineer's contribution to the critical world problem of increasing food production, and also gives an idea of the varied—almost paternal—responsibilities thrown on engineers who take part in such work in the less developed regions of the world.

RICE is the staple food of the Malayan, and it was primarily to increase the rice production of the country that the Drainage and Irrigation Department came into being in 1932, irrigation and land-drainage problems having been a responsibility of a branch of the Public Works Department prior to that date. Traditionally the Malay (as distinct from the Malayan) is a *padi* planter, and the land policy of the country has resulted in rice cultivation remaining almost entirely in the hands of the Malays. Though many hundreds of areas of varying size go to make up the total area of 800,000 acres under wet *padi*, the most extensive areas lie in the coastal plains in the northern part of the country, particularly on the west coast.

The maturation period of rice varies from about four to eight months, according to the variety planted. The total monthly water requirement on average Malayan soils is roughly 12in depth. Mean annual rainfall in most parts of the country is in the neighbourhood of 100in and at first sight it might be expected that a suitable season or seasons could be selected in which it would be possible to grow rice successfully without assistance by irrigation. This is not the case, however, for wet weather is not always sustained even during monsoon periods and monsoons are uncertain in their effective dates.

With one important exception the short river systems and steep hinterland of Malaya have precluded the economical development of valley storage schemes. All other schemes depend on gravity diversion of water from rivers, or on pumping from rivers and on conservation of rainfall within the *padi* areas themselves.

Schemes of this type are simple enough in principle, but even the smallest requires a great amount of detail work in order to assure efficient working, usually with a limited water supply, and without interfering unduly with existing land settlement. A high degree of efficiency is absolutely essential, for it is not a case of giving something where there was nothing before. It is usually a case of replacing a declining but not yet entirely unserviceable system by something better and permanent. The established *padi* planter is not slow to criticise, and sometimes to obstruct, and a most important part of the work of the engineer before and during construction of such improvement schemes is to convince those who are inevitably temporarily inconvenienced that good will come of the work.

Though the development of such schemes eventually involves many authorities, the initiative and early planning fall almost entirely on the engineer, who has to be also the driving force for nearly every aspect of the scheme until completion. On completion he has to take the initiative in forming and sustaining a local irrigation area advisory committee, of which he is invariably the secretary. He also becomes responsible for maintenance and operation of the scheme and for the maintenance of law and order in irrigation matters. It will be understood then that the duties, responsibilities, and problems of the engineer are not by any means confined to planning and construction of drainage and irrigation works.

Salor Pumping Scheme

Only since 1938 have engineers of the Drainage and Irrigation Department been posted for normal duties in the north-eastern State of Kelantan, and in the period since then the Japanese occupation has intervened. Consequently the initial weighing up of the situation is scarcely over. The planning and execution of the Salor scheme was part of the general process of weighing up, and the scheme was intended also to serve as a demonstration of the value of guaranteed irrigation in an area which had hitherto relied almost entirely on conservation of rainfall in the fields themselves. The river is still in the stage of building up its banks, and the general fall of the land is diagonally away from the river and towards the sea. Only in high flood does the river overflow its banks. It will be understood then that in the 150,000 acres of *padi* land through which it flows there are no streams which carry any appreciable amount of water in dry weather. The only possible source of irrigation water is the river itself. The lie of the land would lend itself quite well to irrigation from a barrage in the river, but the river being a large one the cost of a barrage would be high.

The response of the land and the reaction of the people to irrigation was not positively known, and it was clearly necessary to learn a good deal before considering very seriously a comprehensive and costly irrigation scheme for the whole area. The Salor scheme of 3100 acres was designed as the guinea pig. From the very start it was realised that there was going to be some initial opposition. It was also known that day-to-day operation of the scheme when completed would be by local subordinate staff, initially unskilled in the art of water control. In order to win the minds of the people it was essential that it should work properly from the start, in spite of some non-cooperation and a certain amount of clumsy handling in the first instance. The general layout of the scheme is shown in the diagram. The area is divided into four blocks, *A*, *B*, *C*, and *D*, of approximately equal size, and the water control system is designed to deliver one-quarter of the pumped irrigation supply to each block, with the minimum of human interference. Blocks *B*, *C*, and *D*, are divided into three sections each and the fourth, block *A*, where the land is rather irregular, is divided into a greater number of sections. In each block only one section is irrigated at any given time. The section being irrigated therefore receives one-quarter of the total supply. Rotational irrigation of this sort is not usually practised in Malaya, since soil conditions and methods of cultivation do not make it particularly attractive. In this case, however, it was considered that it would be advantageous for the following reasons. First, the soil in this area is rather thirsty at the beginning of the season before it becomes puddled, and a high rate of application would allow more land to be wetted more quickly and would therefore enable ploughing and puddling to get under way over a greater area more quickly. Secondly, the irrigation overseers, as yet unskilled, would find it easier to control at one time a few relatively large streams in a relatively small proportion of the area than a larger number of small streams covering the whole of the area. Thirdly, with irrigation following a regular weekly routine any one *padi* planter would have to turn out only on certain days to control the flow of water on to and across his land. This may seem a curious reason, but it was thought that a man who had rarely turned out at all previously, if he now had to turn out every day, might regard the gilt on his gingerbread as gone. Because it was believed that many of the planters would not turn out anyway, the method of application of water to the land had to be such that it would work nevertheless. Therefore the distributary supplying each section of each block, except for certain awkward sections in block *A*, was laid out very strictly on the contour. Small concrete pipes about 2 chains apart, set at a

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fixed level in the bank of the distributary, ensured an even initial spread of water over the width of the section. Since section boundaries run at right-angles to the contours, water discharged on to the land at the head of the section would run evenly over the land to the bottom of the section, with little tendency to wander and with the minimum of leading, whether or not planters in the section had turned out.

Control is quite simple. Two electrically driven pumps at *E* raise 70 cusecs through 30ft from the river, and deliver to the head of a short section of main canal *EF*. A division control at *F* contains five identical standing wave flumes in parallel. From the diagram it will be seen that half the water will need to be passed to the left branch canal and half to the right branch canal, or one-quarter to the left branch canal and three-quarters to the right branch canal, according to which section of block *B* is being irrigated. Two of the flumes discharge to the left branch canal and three to the right branch canal, and the required division of flow is achieved by closing off entirely one of the left branch flumes or one of the right branch flumes, according to requirements. Since the flow through the flumes is modular, branch canal water levels do not affect the division. Following along the right branch canal, which has a very flat gradient, a double flume control of proportions similar to the flumes of the division control is located at *G* between the distributary off-take controls to sections *B*3 and *C*1. A single flume control is placed at *H*, between the distributary off-take controls to sections *C*3 and *D*1. The off-take controls to blocks *B* and *C* are themselves flumes of similar proportions and each is provided with a two-position gate—open or shut. Off-take controls to the end blocks *A* and *D* are plain open-or-shut sluices. The flow through all the flume controls is modular. The method of operation is most easily illustrated by an example. Suppose that three-quarters of the supply is being passed to the right branch canal, and suppose that the off-take controls to *B*3, *C*3, and *D*3 are open, the rest being closed. Then assuming that the head of water over the crest of each flume is the same, one-quarter of the total supply will find its way to the head of *B*3, one-quarter to the head of *C*3, and one-quarter to the head of *D*3. The hydraulic gradient in the branch canal is very flat and reaches between controls are reasonably short, so heads over the canal-control-flume crests and off-take control-flume-crests would not differ greatly, even if no further control were provided. The canal control flumes are provided, however, with crest-level adjustment. The remaining quarter of the flow, diverted at the division control to the left branch canal, would pass through a single flume control at *J* (which in this particular set of circumstances has no function) and would be discharged to some selected section of block *A*. It will be seen then that the controls having been set for the day, little can go wrong. The water will arrive where it is meant to arrive with very little attention. So much for theory. In practice the scheme does, in fact, work very well. Distribution is very even and planters leading water are generally conspicuous by their absence. Crop-cutting tests in and around the area showed that in the first year of working the increased value of the crop harvested was about £45,000, or nearly double the capital cost of the scheme.

Automatic "Argonaut" equipment making a longitudinal weld on a half-inch thick medium carbon steel cylinder

Automatic "Argonaut" Welding Head

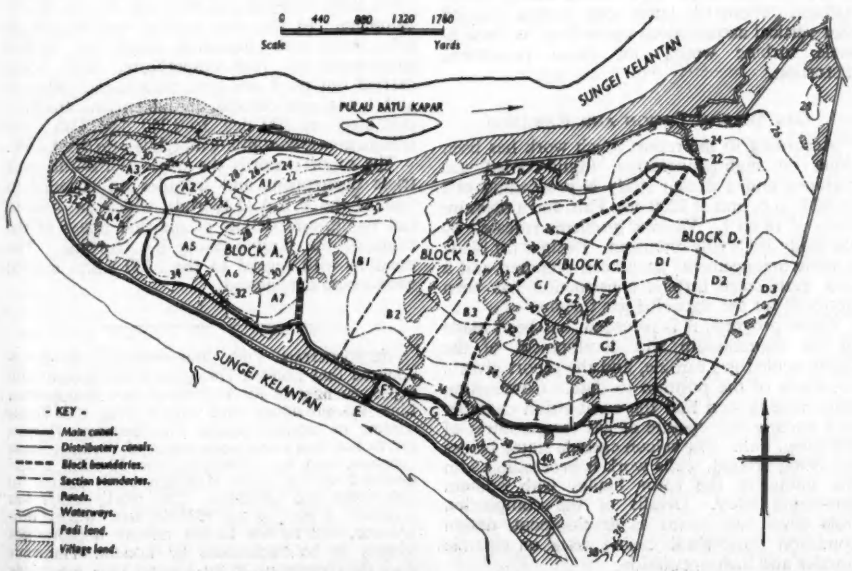
THE illustration above shows a new automatic "Argonaut" welding equipment which is now being made by British Oxygen, Ltd. Hitherto a hand gun has been used for this inert gas-shielded electric welding process and the new head provides a fully automatic means for production welding of heavy sections of metal.

The hand gun is fitted with a variable speed wire feed motor and the arc voltage is maintained constant by self-adjustment through automatic changes of wire "burn off" with changes of arc length. The new automatic head is designed to maintain a constant arc voltage by varying the wire feed speed, and with it constant welding conditions are maintained through the automatic speed regulation of the welding wire feed into the welding arc. It has a simple electrically controlled motor drive which actuates the feed rolls. Two wire speed ranges are provided; at the low speed wire feeds of about 80in to 350in per minute are available; at the high speed the wire feed can be varied between approximately 150in and 450in per minute by rheostat control. For extra high speeds, special gears can be supplied to increase the feed to 750in per minute.

The new head is designed to handle 600A d.c. continuously and can be used with 0·035in, 0·045in, $\frac{1}{16}$in, $\frac{5}{64}$in and $\frac{3}{32}$in diameter "hard wires," such as stainless steel, copper, bronze and steel; also $\frac{3}{64}$in, $\frac{1}{8}$in, $\frac{3}{32}$in and $\frac{1}{4}$in diameter aluminium alloy and magnesium alloy wires.

In addition to the wire feed mechanism the head incorporates a water cooled machine barrel, a reel casing assembly with a mounting bracket, a wire casing to feed the wire from the reel casing assembly to the welding head, a main control panel and a remote control panel. Depending upon the nature of the work to be welded, suitable motorised work positioners, a power-driven head carriage, or other mechanical equipment for moving either the head or the work can be provided.

The 600A composite dry rectifier used with the automatic head comprises a three-phase transformer with primary tappings for 360V, 380V, 400V, 420V and 440V, three-phase, 50 cycle supply, and a fan-cooled dry plate selenium rectifier. Remote control of the whole range of welding currents from 50–600A is effected by a rheostat controlling the current to a magnetic amplifier. A single pole, 600A d.c. welding contactor incorporated in the set is controlled through the welding head.



General layout of Salor pumping scheme

COPPER RESIDUE VALUATION.—The "MECu-DISC" calculator has been evolved to ease the estimation of the value of low-grade residues containing up to 20 per cent of copper. Given the three months' value of metallic copper, in pound sterling per ton, the simple computer immediately shows the value of a residue containing 10 per cent copper and a correction to be applied for every 1 per cent more or less copper present. The calculator is available from Metallic Extractors (Non-Ferrous), Ltd., Marsh Lane, Water Orton, Warwicks.

Pametrada's Progress Report for 1955

PAMETRADA has issued its report for 1955. Therein it is stated that firms which are associated with the marine industry may now become associate members of Pametrada, and the hope is expressed that a formula may be found to admit firms which are not so connected. The activities of the Research Board and other technical committees are briefly noted, together with the items discussed by them : there is a list of fourteen research reports issued to member firms, nine contract reports sent to the Admiralty and five sent to individual firms. There is a record of papers read by members of the staff, including " Predication and Measurement of Vibration in Marine Geared Shaft Systems," written by the late Mr. H. G. Yates, and read by Mr. J. B. Terrell, before the Institution of Mechanical Engineers. Dr. T. W. F. Brown presented " Gas Turbine Engined Installations " at a symposium on " Advanced Machinery Installations Designed for Maximum Saving in Weight and Space," read before a combined meeting of the Institute of Marine Engineers and the Institution of Naval Architects, and other papers were : " Research in Marine Gears and Bearings," given by Mr. A. D. Newman, at the Royal Naval College, Greenwich ; and " The Application of Liquid Metals to Reheating in Steam Turbine Plant," by Mr. B. J. Terrell, which was published in a technical journal.

An account summarising Dr. Brown's impressions of his visit to a number of engineering establishments in the United States of America is included in the report. It is also noted that approval has been given for the construction of a new research building. Then, there are remarks about the open week held in October last, together with graphs which show the percentage reduction in weight of turbines and gearing since 1945, the percentage reduction in fuel consumption, and the aggregate shaft horsepower of steam turbines for merchant ships built from Pametrada designs. Two further courses of instruction on marine geared steam turbine machinery have been held during the year, and the report mentions that six Pametrada and two joint Admiralty-Pametrada patents have been applied for while the association has been granted ten full patents, together with a number of patents granted by other countries. The staff total is given as 344, and it is stated that it has been determined that the establishment can amount to 397.

Steam Turbine Design and Research

A section of the report deals with the work of the design department, which handled ninety-six design inquiries and provided final designs for many of these. Special high-temperature investigations were carried out and progress was made on the basic design for a unidirectional single-cylinder turbine driving through hydraulic reverse gearing. Twenty-seven trials were attended, including the liners " Southern Cross " and " Ivernia." Four oil tankers using steam at 850 lb per square inch and 850 deg. Fah. were completed, and other tankers completed at home and abroad brought the total of such ships to twenty-nine. Valuable design information has resulted from torsional and axial vibration investigations, and the report mentions the completion of the first double-casing h.p. turbine and the introduction of spring-backed gland strips, which, it is felt, will eliminate permanent bending of the rotor. Many of the gearing design inquiries referred to the Pametrada reversible hydraulic transmission system. There is a reference to gear cutting hobs and mention made of the progress of the 30/90in gear grinding machine. During the year the design study of pressurised combustion boilers has progressed, and the separately fired superheater, which superheats steam at 1100 lb per square inch from 950 deg. to 1100 deg. Fah., has been modified for research work on heat transfer problems.

Additional instruments received in connection with the research scheme, Noise Reduction of Machinery (Admiralty), are listed, and the position with regard to the manufacture of the rig for the gear noise test is reported. Noise and vibration measurements were made on the gearing for H.M.S. " Keppel," and it is stated that a modified pump driving system resulted in a reduction of 10 db in overall noise level. Measurements of noise produced by an automatic valve in the " Y " evaporator room in H.M.S. " Eagle " were made, and noise and vibration measurements were taken of the machinery in H.M.S. " Hardy " and H.M.S. " Whitby " during trials. Other investigations related to a feed pump, resilient mounting of " Daring " class gearboxes, and the axial and torsional vibration characteristics of the main machinery of H.M.S. " Savage," also to the noise produced by a turbo-generator in H.M.S. " Owen," while noise and vibration measurements were taken upon a forced draught blower and two turbo-blowers.

It is reported that the first-stage rotor of the high-temperature steam turbine (" Pamela ") has been rebladed with Rex 448, Nimonic 80 and G.18 B. blades, with each shroud section of the same material, and that no deformation of the shrouding occurred when subjected to an overspeed test producing 25 per cent increase in normal stress. Power runs have been carried out and the condition of the piston valve showed that it was suitable for nozzle control at temperatures up to 1200 deg. Fah. A note on the electric heater dryness fraction measurement system states that it showed that the reduction in exhaust wetness, obtained with water being extracted at the three drainage belts, varied between 20 to 30 per cent. Experimental evidence has supported the possibility of the clamped pin mode of vibration and a survey of blade fatigue failures has shown the cause to have been vibration in this mode. The importance of good riveting is stressed and a statement made that a binding wire fitted just above mid-span of the blade would force the whole pack to vibrate in phase in all likely modes. There is a report on the single-stage air turbine scheme which mentions that the newly designed blades, when tested in the supersonic wind tunnel, accepted at inlet a Mach number of 1·5. Other research items touched upon in the report refer to the testing of various gland strips, progress with the high-speed wind tunnel, the completion of the mechanical and thermal tests on the quarter-scale model of the 9000 h.p. double-casing steam turbine. From the latter tests it was assessed that vertical accelerations up to 20 g. in the full-scale turbine would not cause permanent distortion.

Gas Turbine Design and Research

According to the report much work has been done on high-temperature, liquid-cooled gas turbines, and a design study is proceeding of a 10,000 s.h.p. unit of 2200 deg. Fah. and a pressure ratio of 16 to 1. Various problems revealed by the study are briefly discussed. Designs for blade cooling arrangements have been prepared and a new multi-stage turbine construction has been designed for the uncooled gas turbine.

Good progress, it is recorded, has been made in the manufacture and development of the liquid-cooled gas turbine, and the report gives a summary of the position to date. Combustion tests have proved that the combustion chamber and ducting can operate at gas temperatures of 2200 deg. Fah. The silicon carbide stator blades are being ground, while work is proceeding with the filling of the rotor blades with sodium potassium alloy. Details of the combustion tests cover such items as development, design condition tests, blade casing, tests on ceramic nozzles and instrumentation.

An apparatus for determining droplet distribution within the conical envelope of a fuel spray was completed, and has given consistent results, and a rig has been designed and built for work on the combustion chamber development scheme. A counterflow rig to obtain information on the effect of ash deposition on heat exchanger performance is reported to be in an advanced state of construction and a rig built in which flat plate specimens of blading material can be held cantilever fashion with stresses up to 5000 lb per square inch, while using air pressures of 1 lb per square inch gauge. In the liquid blade-cooling programme circular tubes of various diameters, and various heated and cooled lengths, have been tested with water, mercury and sodium potassium alloy fillings over a range of heat input rate and up to 6000 r.p.m. A method has been developed for producing hollow blades of impulse cross section.

Transmission Gears and Techniques

The report recalls that the trials of the first set of test gears in the first reduction gear trials were completed in 1954 and states that the second set of gears, of case-hardened and ground pattern, with teeth of 6 D.P., have been loaded to 578K in a proving run and later, at 28,000 h.p., equivalent to a loading of 1350K when a tooth broke due to fatigue. In the Pametrada back-to-back trials, using a pinion of 3½ per cent, 40 to 45 tons per square inch nickel steel and a wheel rim of 35 to 40 tons per square inch carbon steel and a standard mineral oil, tooth breakage occurred at a loading of 488K. A second set of gears, it is stated, is being prepared ; a list is given of other test gears being manufactured. Journal bearing tests on light and normal oils have been completed, the length/diameter ratios being from ¾ to ½, and a high-speed machine, loaded on the " nut-cracker " principle, has been constructed to investigate the performance of water-lubricated bearings. A scheme to improve " A " bracket bearing design has been put in hand. A " Metastream " flexible coupling is reported to have run satisfactorily at 50 per cent overload with an axial extension of ¼in and lateral misalignment of 0·050in. A further item on bearing research announces a new method for measuring bearing attitude, employing a fully annular capacitance.

With regard to the astern converter, development by means of a model indicated that no further improvement of any magnitude can be expected from this method. Work on the lubrication of sliding and rolling surfaces under load made some progress and, using a 6/10in pitch, 16 deg. rack tooth as basis, some work was carried out on the single-tooth test machine.

Section 4 of the report is concerned with instruments and mentions photo-elastic analysis using a 6/10 rack tooth model in Araldite B, and the introduction of transistors in electronic circuits. The low-frequency wave analyser, having a range from 1 c/s to 100 c/s at inputs from 1mV upwards, is reported to be nearly complete. In the next section new techniques are dealt with including work on surface treatments for high-temperature, tests being carried out on 1 per cent chrome-molybdenum and 1 per cent chrome, molybdenum-vanadium bolt steels at 800 deg. to 1050 deg. Fah., and using a grease containing molybdenum disulphide.

The report records the work of the full-scale trials department and includes an account to date of the Y.E.A.D.I. trials, which are now in full swing, and details of the first phase of the trials of the double-casing h.p. turbine. The position with regard to the 3500 s.h.p. marine gas turbine is reviewed.

Metropolitan Line Improvements.—It is announced that London Transport is to proceed with a pre-war scheme for improving the Metropolitan Line by providing four tracks over the 7-mile section of double-tracked line between Harrow North Junction and a point north of Watford South Junction, and by electrifying the 10-mile steam-operated section from Rickmansworth station to Amersham and Chesham. This work, which was originally a part of the 1935/40 new works programme, will be the largest railway improvement scheme to be undertaken by London Transport since the completion of the Central Line extensions in 1949.

Industrial and Labour Notes

Railwaymen's Wages

During its annual conference at Great Yarmouth last week, the National Union of Railwaymen decided that it would approach the other two railway unions with a view to the formulation of a common wages policy. The resolution passed by the conference indicated that such a policy would take into account the increased productivity on the railways, a matter, it was declared, which had not yet been reflected in wages. At the same time, it was made clear that should it not be possible to reach agreement with the other unions, the N.U.R. would proceed with a wage claim on its own. Another resolution passed by the conference directed the N.U.R. executive to press immediately for the introduction of a forty-hour week.

Before the end of last week, however, it was reported that another railway union, the Associated Society of Locomotive Engineers and Firemen, had asked the British Transport Commission for an early meeting to discuss a claim for a 15 per cent increase for footplate men. The submission of this claim follows a resolution passed at the annual conference of A.S.L.E.F., which was held a few weeks ago. The existing weekly rates for drivers and motormen range from £9 8s. 6d. in their first year to £10 12s. in their third year ; the weekly rates for firemen and assistant motormen are from £7 15s. to £8 15s. 6d.

National Union of Mineworkers

Last week, the National Union of Mineworkers held its annual conference at Ramsgate. It began with an address by the president, Mr. Ernest Jones, who spoke about the need to stop the wastage of skilled and experienced men from the coal mining industry. Still more must be done, he said, to close the manpower gap and to make the industry more attractive. The biggest contribution to that end, Mr. Jones suggested, would be a reduction in working hours, which, he asserted, were longer now than they were thirty years ago. He went on to say that if stoppages were reduced to the minimum, restrictions on output ended, and attendance improved, it should be easy to secure the required output per man-year working a seven-hour day underground and a forty-hour week on the surface. Such a concession, Mr. Jones claimed, could attract to the industry 12,000 or 15,000 more men, many of whom would be experienced miners.

On Wednesday, the chairman of the National Coal Board, Mr. James Bowman, addressed the conference. In the course of his speech he referred to the Board's revised *Plan for Coal*, and went on to say that to-day one did not approach an argument for increased coal production in any fear of "over-production and so redundancy." Britain's major task, Mr. Bowman emphasised, was to build up the coal mining industry into the most efficient, the most productive and the most powerful in the country. He believed, he said, that full employment could only be sustained by high production and efficiency, and, if Britain was to continue as a great nation, an essential part of her greatness must lie in the efficient development of her coal resources.

Mr. Bowman then commented on coal production figures, which, he pointed out, were "examined very carefully by all concerned with the industry." When it was seen that last year, he said, after nine years of nationalisation, almost 3,000,000 tons of coal were lost in disputes, the critics claimed that nationalisation had failed. Mr. Bowman added that he knew the strike weapon was the last resort of the workers "in their age-old struggle for social justice," but he urged that it should be the last resort and not the first, as was all too often the case to-day. He then pointed to the danger of losing the benefit of technical advances through disputes or increased absence. The Board had estimated, Mr. Bowman said, that increased power loading led to an increase of 2,250,000 tons in total output during the twelve months ended March last. But over the same period, he observed, increased absence alone caused the loss of 1,250,000 tons, so that the advance in one direction was more than half lost by a falling off in another direction. The union, Mr. Bowman commented, could not stand that at a time when it was pressing so hard to improve living and working conditions. Furthermore, the Board could not afford to throw away the advances based on capital outlay and improved technique.

National Coal Board Organisation

The National Coal Board has announced the setting up of a new department at its headquarters to carry out the work specified in the *Plan for Coal*. The reconstruction department, as it is to be called, will have the responsibility of ensuring that the plan is kept under review and is adjusted as may be required, and that major projects, whether for new sinkings or for the reconstruction of existing collieries, are planned and progressed with the maximum speed and efficiency. Mr. H. E. Collins, who up till now has been production director in the Durham division, has been appointed director-general of reconstruction. The new department is to come under the responsibility of Dr. W. Reid, who is the Board member for production ; he desires to concentrate on coal production and reconstruction matters, and the responsibility for carbonisation will now therefore pass to Mr. A. H. A. Wynn, the Board's scientific member.

Productivity

The British Productivity Council has published a report entitled *Policy and Progress*, 1955–56, which reviews its activities over the past twelve months, and presents also some account of its work since its inception in 1953. The council, it may be recalled, has no executive powers ; its function is to create a greater appreciation of the need to increase productivity, and a better understanding of the means by which that can be achieved.

The report makes the comment that the Government's recent restrictive measures on spending and credit have, with other factors, affected output per head. The annual rate of increase in 1955, at 2½ per cent, was about ½ per cent less than in 1954 and 1953, but it was still 60 per cent higher than the average rate of increase in the pre-war years. This country's output per head, the report explains, remains the highest in Europe. Yet, it is emphasised, our productivity is not high enough to meet both the increasing demand for consumer goods and new investment, with expenditure on armaments and public services. There remains a clear alternative, the report adds ; either the standard of living can fall to the level warranted by this country's present productivity, or that productivity can be raised, by the use of modern techniques, to the point where it can support our demands. Against such a background, the report asserts, the work of the British Productivity Council has "an obvious urgency."

Employment and Unemployment

A report by the Ministry of Labour on the employment situation in Great Britain shows that at the end of May there were 23,008,000 people (15,246,000 men and 7,762,000 women) in civil employment. That was 20,000 more than at the end of April.

Of the total, 3,996,000 were employed in the basic industries. Compared with the preceding month, the principal employment changes in these industries during May occurred in agriculture (an addition of 15,000) and transport (an addition of 8000). In coal mining, manpower declined in May by 2000 to a total of 704,000. In the manufacturing industries, the number employed dropped by 35,000 to 9,249,000. Every section classified as "manufacturing" recorded a decrease, apart from the "food, drink and tobacco" group. In the engineering, metal goods and precision instruments group the number employed fell by 10,000 to a figure of 2,793,000, 31,000 above the total returned a year earlier. In vehicle manufacture the number employed in May was 1,246,000, which was 5000 less than in April, but 16,000 more than in May last year. Under miscellaneous trades and services the report shows that employment in building and contracting increased in May by 17,000, making the total 1,505,000, compared with 1,486,000 a year earlier.

The latest unemployment returns issued by the Ministry state the position on June 11th. There were then 222,577 people registered as out of work, or 14,854 fewer than on May 14th. The June figure included 33,049 who were said to be temporarily stopped. About short time working, the Ministry says that in the week ended June 2nd, about 100,000 operatives in manufacturing establishments were losing eleven hours each on the average. On the other hand, in the same week, 1,540,000 production workers were reported as doing, on average, eight hours' overtime. Another matter mentioned in the report is that, in the four weeks ended May 30th, the employment exchanges filled 162,000 vacancies. The number of vacancies notified to the exchanges, but unfilled, on May 30th was 397,000, which was 16,000 more than on May 2nd, but 47,000 less than a year ago.

Steel Industry Dispute

As recorded in these notes on June 29th, a ban on overtime by maintenance workers in the steel industry has been affecting output for several weeks past. The dispute which led to the ban is concerned with a wage increase recently awarded in the steel industry ; the unions involved claim that the craftsmen's differential has not been maintained, but would not consent to arbitration. On Wednesday of last week, the National Joint Trade Union Craftsmen's Iron and Steel Committee met the Iron and Steel Trades Employers' Association to discuss the situation, but no agreement was reached. Subsequently, the Craftsmen's Committee announced that it was recommending a "withdrawal of labour" on Saturday, July 14th, of all maintenance workers in the industry.

At the beginning of this week, conciliation officers of the Ministry of Labour talked over the circumstances of the dispute with representatives of the unions and the employers. It was stated afterwards that the Minister of Labour had decided to set up a court of inquiry to investigate the dispute. In making this announcement, the Minister expressed the earnest hope that, in view of his decision to establish a court of inquiry, it would be possible to restore normal working conditions at the earliest possible date.

Capital Expenditure in 1956

The Board of Trade says that the companies which assist in its regular quarterly inquiry into capital expenditure were asked at the end of April if they wished to revise the forecasts of their expenditure for the whole of 1956. In most cases, they had already submitted their forecasts to the Board of Trade.

More than 600 companies are associated with the inquiry, and the information which has been made available indicates that companies operating in manufacturing industry are now expecting to spend slightly more in 1956 than was anticipated at the end of last year. The estimates show that companies now expect to spend about 20 per cent more this year than was forecast at the end of 1955. About one-third of the companies concerned have revised their earlier forecasts of expenditure on plant, machinery and vehicles in an upward direction, and about one-quarter in a downward direction. About one-third revised their earlier forecasts of expenditure on building in an upward direction, but only about one-fifth have revised them in a downward direction.

The Board of Trade says that, so far as can be ascertained at present, capital expenditure in manufacturing industry during the first quarter of this year was 14 per cent lower than during the preceding quarter, but was 25 per cent higher than in the first quarter of 1955. Expenditure on plant and machinery was 20 per cent higher, on vehicles 15 per cent higher, and on building work 43 per cent higher than in the first quarter of 1955.

Indian Engineering News

BY OUR INDIAN CORRESPONDENT

Atomic Energy in India

The Planning Commission announced recently that an atomic power station with an initial capacity of about 5000kW would be functioning in India before the end of the plan—that is, in about five years' time. This announcement, which took everyone by surprise, was followed by the news of an agreement between the Governments of Canada and India for the establishment of an atomic reactor project under the Colombo Plan. India and Japan are probably the only countries in Asia with a fairly well-developed atomic energy programme. In India, the work is carried out by the Department of Atomic Energy under Mr. Nehru, the Prime Minister, through the Atomic Energy Commission, which functions on the lines of similar bodies in the United Kingdom and the United States. The Commission has recently set up an Atomic Energy Establishment at Trombay, near Bombay, which will be in charge of atomic developments in the country, with emphasis on the industrial aspect, including power generation, and will co-ordinate the activities of a number of plants handling nuclear material, throughout the country from the proposed Nangal fertiliser plant in the Punjab to the thorium-processing factory in Travancore-Cochin in the south (THE ENGINEER, March 20, 1953 ; May 21, 1954).

The Department of Atomic Energy works under the direction of Dr. H. J. Bhabha, F.R.S., who presided over the International Conference on the Peaceful Uses of Atomic Energy held in Geneva last year. The Department's activities fall broadly into three main categories : (1) research, including construction of reactors ; (2) survey and prospecting, and (3) industrial operations. The first reactor to be set up under the reactor programme is nearing completion and is expected to be in operation by the middle of 1956. It is a research reactor designed and constructed by the department's own staff and will use ordinary water as moderator. Fuel elements will be supplied from the United Kingdom. The reactor will enable India to produce radioactive isotopes for biological, medical and industrial research, in addition to training reactor engineers for later projects. The Canadian reactor, which is a gift of the Government of Canada under the Colombo Plan, is expected to be completed early in 1958 and will be in full operation by the middle of that year. The total cost of the project will be about Rs. 7 crores (£5,250,000), of which the Canadian contribution will be a little over a half. Canada will pay the external and India the internal costs.

The reactor will be a high-power, high-flux reactor similar to the well-known NRX reactor at Chalk River, Canada. It will use heavy water as moderator so as to produce intense neutron flux. The requisite heavy water will be purchased from the United States until such time as the proposed heavy water plant at Nangal is commissioned. Canada is providing the reactor itself and the steel for the rotunda which will surround it. The design of the foundations, the rotunda and the reactor will be done in Canada, and the construction of the civil works and a major portion of the erection will be done by Indian contractors under Canadian supervision. Work on the foundations and basement of the reactor has already begun and is expected to be completed before the monsoons. Erection of the steel rotunda will start soon after the rainy season and should be ready by the end of this year. The reactor will be made available to scientists and engineers from the Colombo Plan countries in South and South-East Asia. It will also work in close collaboration with the Asian Atomic Centre which the United States is setting up at Manila.

The raw materials division is responsible for geological and geophysical surveys and prospecting for minerals of use in atomic energy. During the last few years it has been carrying out intensive surveys in Travancore-Cochin, where there are large deposits of monazite and ilmenite. This survey is now nearing completion and the figures are being finalised. Among other interesting deposits revealed by recent reconnaissance surveys are columbite, tantalite, beryl and uranium-bearing minerals in the mica belt of Bihar, and monazite deposits in Nellore, Madras. Exploratory drilling in the Dariba copper mines in Bihar has disclosed uranium ore deposits capable of being used.

The department's industrial operations cover a wide field. It owns the Indian Rare Earths, Ltd., which processes the monazite sands to produce rare earth products and trisodium phosphate. This plant at Alwaye, Travancore-Cochin, has been in production since 1952 and its processing capacity is being increased from the present 1500 tons per annum to about 3000 tons of monazite in order to obtain the required quantity of uranium for the reactor programme. The residual thorium-uranium cake from the Alwaye plant is sent up for further processing to the plant at Trombay (near Bombay), which commenced production in August last year. The capacity of the plant has been increased fivefold in order to fulfil commitments in respect of the supply of thorium nitrate which it produces. This thorium nitrate will be fed into a uranium processing plant which is to be soon set up to produce uranium and thorium from the Trombay chemicals. The fuel value of the thorium and uranium produced at this plant will be equivalent to about 1000 million tons of coal per annum, or roughly thirty times the annual coal production of India, and four times that of the U.K. Two pilot plants are to be set up immediately for (1) the extraction of the uranium ore from the copper tailings of the copper mine at Ghatsila, Bihar, in co-operation with the British-owned Indian Copper Corporation, and (2) the production of titanium sponge metal from the rutile and ilmenite sands in collaboration with Messrs. National Lead Company of America. The Ghatsila pilot plant will initially treat about 200 tons of tailings per day and will be enlarged to take in all the waste material if the process turns out to be economical.

Another important project is the heavy water-fertiliser plant at Nangal, which will utilise the power from the Bhakra-Nangal project for the production of fertilisers and heavy water. Project reports for the joint production of these two items are being prepared by Messrs. Vitro Engineering Division and Messrs. St. Gobain, Chauny and Cirey, whom the Production Ministry has engaged as consultants for the purpose. A project report on heavy water production at Sindri, Nangal and other places is also being prepared by Messrs. Costain-John Brown, of U.K., who have been engaged as additional consultants for the purpose by the department. This industrial operation side of the department's activities is probably the most developed because the Government is said to attach great importance to the place of atomic energy in its future industrial plans. "It is essential that India should be prepared to supply her own uranium," says the latest report of the department, "and produce her own fissile material, if India is not to be relegated to an inferior position in the field of atomic energy. India is the only country in the whole of Asia and Africa, which is in a position to develop fissile resources without external aid."

The Geneva conference last August, over which Dr. Bhabha presided, made India atomic-conscious. The Indian programme has since been oriented towards extracting the maximum benefit out of the thorium deposits of which India has the largest deposits in the world. The conclusions which the Indian delegation drew from the Geneva meeting are therefore significant. According to the delegation, the conference led to four broad conclusions. First, it established that there is enough uranium and thorium widely distributed in the world to sustain an expanding world wide power programme at the maximum rate possible for many centuries. Secondly, breeding was shown as possible in thermal reactors using thorium, and the thorium-uranium-233 fuel cycle was shown to be superior to the uranium 238-plutonium cycle, a conclusion of great significance for India, which has a vast supply of thorium in monazite sands. Thirdly, it was established that in fast reactors breeding is possible with uranium as well as thorium. It will be possible in future to extract as much energy from a ton of uranium or thorium as from between 2,500,000 to 3,000,000 tons of coal. Fourthly, it was established that electricity from large atomic power stations of 100MW or more would be competitive with electricity from conventional thermal stations in regions where coal costs are high and hydro-electric potentialities nil. There are many regions in the world, the Indian delegation's report concludes, especially in the under-developed areas, where electricity would be acceptable at the cost of even 30 mils per unit (which is the estimated cost in an atomic power plant of 2000kW to 5000kW).

India works in close collaboration with other countries in the field of atomic research and development and has formal agreements with some of them. With the U.K. it signed an umbrella agreement in 1955 providing generally for co-operation and mutual help and enabling specific projects for co-operation to be undertaken when mutually approved. In this way, supply of fuel elements for the swimming pool reactor has been arranged. Supply of heavy water for the high flux reactor has also been arranged through another agreement with the U.S. The Canadian reactor has been accepted under the Colombo Plan and a technical assistance agreement has been signed with the U.S. for the supply of nuclear research equipment and apparatus.

The Ganga Bridge

The Ganga Bridge, spanning the River Ganga (otherwise known as Ganges), is one of the biggest bridges under construction in the world at present. When completed in about five years' time, it will consist of fourteen main spans each of 397ft and four shore spans each of 105ft. The main spans will be supported on piers with foundations sunk 190ft to 200ft below the high flood level, and the bridge will carry a broad gauge track on the lower deck and a 24ft wide road with two footpaths, each 6ft wide, on the upper deck. The main girders will be 60ft deep and 29ft apart on centres. As far as is known, the foundations are supposed to be the deepest for any bridge in the world. Work on the bridge has been proceeding since 1954 and a foundation stone was laid by the President of India last February. The cost will be about £6,000,000.

The Ganga is at present bridged at seven places, six in India in the State of Uttar Pradesh, and one near Sara in East Pakistan, about 600 miles downstream from Banares. The river divides the State of Bihar, one of the richest and the most populous in the country, into two parts, and the only means of communication between them are the ferries operating from three to four points in a stretch of about 500 miles. After the partition of India, the problem of adequate communication became most acute and it was decided to give very high priority to providing a bridge somewhere in Bihar, probably near Patna, the capital and commercial centre of the state. Mr. J. W. Fenton, an engineer of the East Indian Railways, was deputed to survey the river and recommend a site for a bridge between Patna and Mokameghat. the latter having figured in a report of the old Bengal and North Western Railway in 1907, Mr. Fenton found that the training works necessary at Patna would cost twice as much as those at Mokameh and the steelwork itself would run into twenty-two spans, as against fourteen at Mokameh. He also warned that the river, because of its characteristic meanderings, might ruin the Mokameh site unless the work was taken in time and the course trained. Mr. Fenton's warning came none too soon, because in the high floods of 1948 the river bifurcated 3 miles ahead of Hathida, where the bridge is now being constructed. Incidentally, Mr. Fenton was the last of the distinguished line of British engineers who have been connected with the Ganga, the first being Major Rennel, who first surveyed the river or a part of the river in 1779. The next survey was by Major R. H. Colebrook in 1801, and another was undertaken by Capt. H. W. Prinsep in 1828. The first bridge on the Ganga was built in 1874, at Rajghat, between Bareilly and Aligarh in Uttar Pradesh.

The Ganga is an alluvial river and hence subjected to a very varied pattern of meanderings,

which constitute the principal problem for navigators. The river at the present bridge site has a catchment area of 293,000 square miles, the maximum discharge being estimated at 2,750,000 cusecs. In winter, the water level falls to 112ft above sea level, rising to 140ft during high floods. The right bank, which is a high bluff of strong clay going down to about 50ft, is 34ft above the winter water level, but the left bank, which consists of a mixture of fine, medium and coarse sand, is subjected to erosion during floods and it is only 18ft above the river bed. The river is divided into two streams about 3 miles upstream from the bridge, the division continuing a few miles downstream, the discharge being distributed in the ratio of roughly 3 : 7 between the left and the right channels. From a study of these channels in the past, it appears that one complete cycle from the left bank to the right bank and back again takes a period of about seventy years. The problem, therefore, was not only to decide on the width of the waterway to be allowed under the bridge but also to design protective works to maintain the river well "trained." Model experiments were undertaken at the Central Water and Power Research Station at Poona and the report by Mr. D. V. Joglekar, the Director of the Station, makes interesting reading.

A model covering a reach of 50 miles above the bridge site and 17 miles below was made to a scale of 1/560 horizontal and 1/67 vertical. The bridge alignment as proposed for the project was found to be hydraulically flawless, the best angle between the current direction and the alignment being measured at between 86 deg. and 90 deg. The bridge would span the right channel only, the left channel would be gradually "killed." To accomplish this, it was decided to provide one guide bank on the left, the bank serving a dual purpose of protecting the approach embankment from river attack and controlling the river to induce it to flow more or less axially under the bridge. A number of lengths were experimented with and it was found that a length of 5000ft would be suitable for the purpose. A longer length directed a strong current against the unprotected south bank ; a shorter length, on the other hand, was found to give insufficient protection to the approach bank. With a length of 5000ft, the flow through the proposed spans would be more or less uniform and the scour reduced to the minimum. The findings of the research station were confirmed by Sir Claude Inglis (formerly director of the station), who flew over the area and inspected the site. The site was also approved by Sir M. Visveshwarayya, an Indian consulting engineer.

The main girders of the bridge are to be Pettit trusses, somewhat modified at the ends, with the top and bottom chords parallel. Each truss will consist of sixteen panels and will be 60ft deep. The railway track will be carried by a welded floor system bearing on the bottom chords, and the roadway will be carried on an upper floor, about 18ft above the rail level. All the steelwork will be welded. The quantity of steel required for the main girders is of the order of 13,000 tons, most of which is to be imported from Great Britain. The main piers will be founded on monoliths about 54ft long by 32ft wide, with semi-circular ends. The piers will have a solid base up to 2ft above the highest flood level and will then have two circular columns each of 15ft diameter. The monoliths will have to be sunk 165ft to 175ft below the river bed.

Stone pitching of the order of 25,000,000 cubic feet will be needed for many of the protective works and a good proportion of this has to be brought from distances as great as 50 to a 100 miles. For the foundation work alone, plant and machinery worth Rs. 60 to 70 lakhs (about £500,000) has been assembled at site, and the labour force at present is of the order of 15,000, including people working in the quarries. The target date for erection of the main girders is March, 1959.

Construction of the bridge is under the supervision of the Railway Board. The main contractor is the Ganga Bridge Construction Company, Ltd. The foundation work is being done by Hindustan Construction Company, Ltd., and the contractor for the bridge superstructure is Braithwaite, Burn, Jessup and Co., Ltd.

African Engineering News

BY OUR AFRICAN CORRESPONDENT

South African Railways : General Manager's Report, 1955

In assessing actual transport accomplishments the most obvious and possibly the best yardstick is the tonnage moved. During the period April 1st to July 31st, the latest finalised returns, 24,590,249 tons of traffic were transported by rail in comparison with 23,711,466 tons during the corresponding period last year, an increase of 3·7 per cent. If it is assumed that this percentage increase is maintained, and there is no reason to suppose that it will not be, the 50,000,000-ton mark should have been passed by the end of November. Traffic moved during the first eight months last year amounted to 48,269,373 tons, hence the first eight months of the present year may be expected to see an improvement on the corresponding period last year of 1,800,000 tons.

The total quantity of coal moved by rail during the first eleven months of the year (January to November) amounted to 23,499,975 tons, an advance over the corresponding period last year of 363,459 tons. Private consumption accounted for 17,009,789 tons, which is 446,656 tons more than last year. Locomotives used 205,096 tons more, but exports at 308,032 tons, represented a reduction of 288,293 tons in comparison with last year.

The recent announcement that thirty-five class "GMAM" (Garrett) locomotives had been purchased for approximately £3,000,000 by the Railway Administration served to draw attention to the heavy purchases of locomotives since the end of the war. The latest returns show that tractive effort available increased from 69,984,778 lb at March 31, 1945, to 99,819,930 lb at March 31, 1955. The railways, at the end of last March, had 2668 steam and 268 electric locomotives in service.

Apart from the purchase of goods wagons overseas and from private industry in South Africa, the Railway Administration, during the period April 1, 1943, to March 31, 1955, built 11,312 goods wagons in its own workshops, at an approximate cost of £10,598,580. A railway wagon-building industry, started in South Africa in 1944, had, by the end of August last, supplied the railways with 16,324 trucks at a cost of £19,765,040, and has since then received an order for another 2200 wagons, bringing the total to be supplied by this one firm to 18,524 trucks at a total value of £23,557,148, a striking indication of the importance of railway buying in the promotion and welfare of certain kinds of industrial enterprise.

As a result of the substantial additions to the truck establishment, and taking into account the number of vehicles withdrawn from service, the merchandise-carrying capacity was increased from 1,482,997 tons on April 1, 1945, to 2,639,318 tons at March 31, 1955.

Nearly £8,000,000 has been invested by the Railway Administration in the motor vehicles and trailers operated by the Road Transport section. The year has been encouraging from several aspects, although decreases were recorded in the number of passengers and livestock carried. The goods tonnage transported showed a slight increase in comparison with the previous year. The road transport services are now being operated over a route mileage of 27,186. Several important new services were introduced during the year, including long-distance services for non-Europeans in various provinces.

In October, 1954, it was decided as an emergency measure to use road transport to assist the South African Railways to clear up congestion at some railway stations and in goods yards. The experiment has been an unqualified success. From October 1, 1954, to November 30, 1955, these ancillary road services moved 513,151 tons of traffic. These services have been most effective in ensuring quick delivery of goods delayed by rail congestion.

Capital invested in the harbours of South Africa stood at £30,754,603 at March 31, 1955, and another £8,000,000 will be spent on improvements at the various ports, bringing the total capital to nearly £40,000,000. This formidable investment has been made necessary by the large number of ships calling at Union harbours and by the ever-increasing tonnages of import and export traffic which have to be handled. Harbour activity may be regarded as another yardstick to measure the economic growth of the country.

South African Airways showed a surplus of £580,963 for the year which ended on March 31, 1955, the highest annual surplus ever recorded. The process, started with as little delay as possible, of equipping South African Airways with bigger aircraft, will be carried a step further this coming year, when three Douglas "DC-7B" aircraft are placed in service. It will be possible to use the new aircraft either entirely for standard class passengers, or partly for standard class and tourist traffic, or entirely for tourists. South African Airways will be the first airline outside the United States to use the "DC-7B."

The report concludes with the hope that with all the new resources that are being provided, the railways will be found to be adequate in every respect to the needs of South Africa.

Diesel Traction

A technical commission to study the various types of diesel locomotives used by overseas railways, to make an on-the-spot investigation of performance and to make recommendations as to the type of locomotive most suitable for South African conditions, left South Africa in February last for various European countries, the United Kingdom, the United States, Canada, Australia and New Zealand. The mission will consist of five members of the South African Railways' staff, four of whom are prominent engineers in the organisation. The European countries scheduled for visits are Italy, Switzerland, Western Germany, France, Belgium and the Netherlands. The terms of reference of the mission are to study diesel locomotives in factories and under working conditions, with special attention to performance and suitability for Southern Africa conditions. In terms of a resolution taken at a recent conference of Central and Southern Africa railways, the mission will be accompanied by representatives of the Mozambique Railways, the East African Railways and Harbours, and the Nyasaland Railways. It is of interest to recall that the S.A. Minister of Transport announced some time ago that the South African Railways would probably require 140 diesel shunting locomotives and sixty diesels for main line traffic.

Superphosphate Plant for Salisbury

Plans for the establishment, near Salisbury, Southern Rhodesia, of a plant for superphosphate manufacture, and other works, at a total cost of more than £3,000,000, have been announced. The plans of the Rhodesian company, African Explosives and Chemical Industries (Rhodesia), Ltd., have been completed and the construction of the plant will begin in the near future. Superphosphate has hitherto been imported from the Union and from overseas, but the new plant will have an initial capacity sufficient to meet the need for superphosphates for fertilizer purposes in the Central African Federation for some years ahead. The two parent companies behind African Explosives and Chemical Industries in this venture are De Beers Consolidated Mines, Ltd., and Imperial Chemical Industries, Ltd.

New Telephone Equipment Factory at Germiston

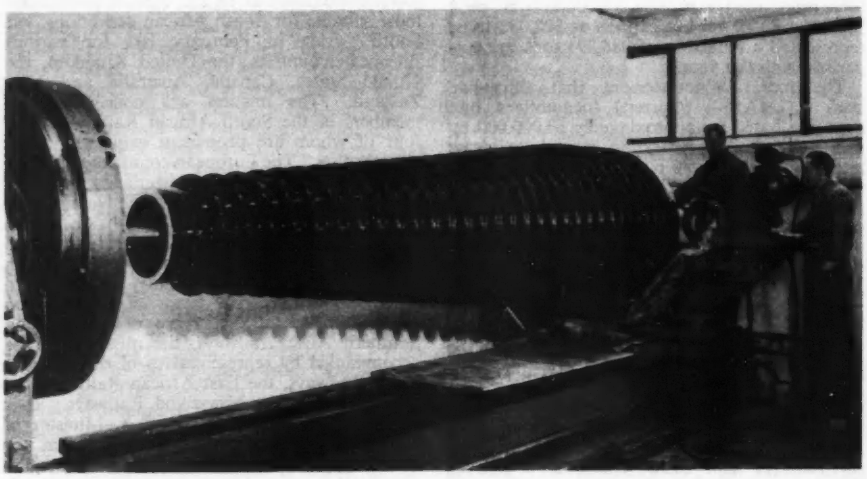
A new industry came into being in South Africa recently with the opening of the Union's first automatic telephone equipment factory at Wadeville, near Germiston. This Wadeville plant will, within five years, be able to manufacture the equipment for 20,000 lines a year. By that time, 500 machine setters and other craftsmen will have to be trained for the industry ; many semi-skilled workers will also be required for assembly.

The primary interest of the factory, which has been financed by overseas companies, will be to manufacture automatic telephone equipment. More than £1,000,000 has been invested in the project, which should help the Union to overcome the post-war overloading of its telephone system.

Insulators for 380kV

IN the construction of high-voltage equipment, ceramic insulators, besides their primary electrical function, constitute mechanical elements in the design ; as such they frequently have to withstand substantial forces. Even the wind forces can, in the case of the tall insulators required for 380kV gear, give rise to substantial bending moments. Another factor is the internal air pressure, in cases where compressed air is conducted through the insulator to the switch chamber. Design and testing have to take account of such aspects as resistance to bending, torsion, impact bending forces, and internal pressure.

While the present tendency still is to subdivide large insulators, some very large single insulators have recently been made by Stemag Steatit-Magnesia Aktiengesellschaft, Holenbrunn (Bavaria). Our illustration shows one such insulator during manufacture. It is 4m long and designed to withstand a test voltage of 1,000,000V. The material is porcelain ; maximum electrical strength is developed if the porcelain, which is a system of kaolin, feldspar and silica, contains a high proportion of feldspar, while high mechanical strength is obtained with a large proportion of silica. When tested with fuchsine solution under pressures of 150–300 atmospheres, no absorption must occur.



Single insulator during grinding operations. The insulator is 4m long and has to withstand a test voltage of 1,000,000V

Another kind of material, especially for applications where great mechanical strength is required, is Steatite, of which important deposits occur in the district. The strength of this material is some 50 per cent above that of hard porcelain.

In all ceramic substances it is found that great variations in strength occur in different articles made of nominally the same material. It has also been found that the ultimate strength decreases with the size of the cross-section. No complete explanation of this has been given but it seems likely that the drop in strength with size is caused in part by internal stresses building up during manufacture.

Whatever the reason, it has been found that while small porcelain specimens can withstand bending stresses up to 400 kg to 700 kg per square centimetre, for sections of 10 square centimetre area this figure drops to about 180 kg to 380 kg per square centimetre, while for 600 square centimetre area and over the range of ultimate strength is about 80 kg to 160 kg per square centimetre.

Owing to the number of variables over which only a limited control is possible, such as slight variations in the composition of the raw materials, fineness of grinding and moisture contents, and the errors during moulding, the size tolerances of the finished product are fairly large. To variations due to the above factors must be added the shrinkages during drying and firing, so that altogether the overall length will be subject to a tolerance of the order of ± 2 per cent. Corrections by means of grinding can be carried out economically only at the ends.

Testing is carried out with the help of ultrasonic equipment operating at 1 to 5 Mc/s. The ultrasonic beam sent into the test piece by the generator is reflected back at the far surface and the time taken to reach the front again is shown directly in terms of distance on a cathode ray tube screen, where any voids or inclusions are also clearly shown. In addition, the equipment permits a measurement of the absorption of the ultrasonic waves within the material. This allows an estimate to be made of the degree of porosity, and to distinguish porous bodies from those fired to a normal degree. Since sound absorption increases with frequency, the higher frequencies, of the order of 5 Mc/s, are most useful for this kind of test.¶

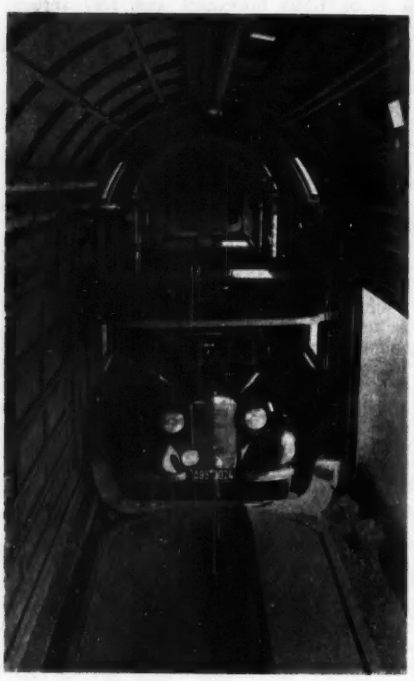
One of the more controversial questions has been that of thermal testing. Many of the tests successfully employed on small insulators are far too severe for large sizes, on account of the greater thermal stresses which are caused. Observations carried out in the French Alps have yielded information on what the rates of change of temperature at the surface of an insulator might be in practice, under the most unfavourable conditions. It was found that such conditions were realised if the surface were exposed to strong sunshine and subsequently cooled by a cloudburst. In such cases the rates of change of temperature obtained were of the order of several hundred degrees Centigrade per hour. On the other hand, quenching in water with a differential of 70 deg. Cent. produces rates of temperature change ten times as high, which often cause damage to the test piece. This is not surprising, for the thermal diffusivity of air is 0·023 kilocalories per metre-hour-deg. Cent. (twice that during rain), while water has a diffusivity of 0·477 and porcelain 1·2 ; the coefficients of heat transfer to water and air are in the ratio of approximately 120 : 1.

The most critical parts of the insulator in these quenching tests are the ends, on account of their increased thickness, and the larger heat loss from the greater amount of surface exposed. Where failure of an originally sound test piece takes place, it usually does so after an interval of a minute or two, which is when the induced thermal stresses have reached a maximum value.

For a satisfactory electrical performance, the flashover voltage during rain is the decisive factor and this is the quantity now given in international specifications. In the case of insulators for 380kV used with equipment having a permanently earthed star point, a steady alternating voltage of 750kV, and an impulse voltage of 1450kV have to be withstood. In conditions of rain, a voltage of 750kV corresponds to a flashover distance of about 3500mm.

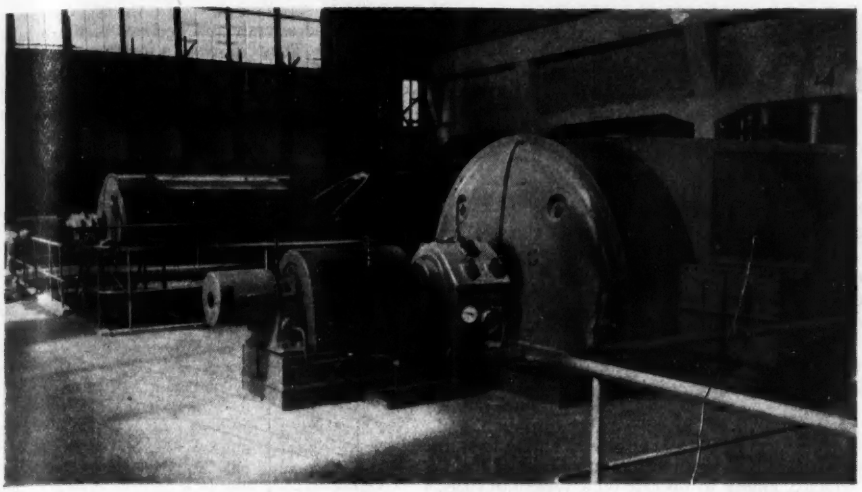
Automobile Transporter Wagon

A transporter wagon by means of which cars can be sent by passenger express trains is being introduced by the German Federal Railways. Our illustration shows the interior of the wagon, which can accommodate a total of eight large cars on two storeys, or alternatively forty-two roller-mounted pallets with luggage. The wagon weighs 42 tons, is 26·8m long, 2·82m wide, and 4·24m high, and can carry 22 tons. In addition to the cargo space, there is a compartment for the guard, with sleeping accommodation and a toilet. Daylight is admitted through a number of small windows in the sides and roof. For loading cars or luggage, each side of the wagon is fitted with a roller door, which is over 5m wide and can be opened by being mechanically raised upwards within the curved space under the roof. In consequence, the door can be opened on one side only at a time, but this is considered sufficient. Inside the door is fitted a lifting platform, which also incorporates a turntable. The turntable is swung out and the car is driven on to it and swung inside. It can then be driven into position on the lower deck or raised to the upper deck by means of the lift. Through the use of a turntable it becomes unnecessary to drive the car out on to the platform in reverse, which often is an awkward manœuvre.



Automobile transporter for eight cars or equivalent weight of luggage. In the foreground is the drive-on turntable/lift. In use with passenger expresses its speed is 140km per hour

When the wagon is being used for luggage the lifting platform can take six pallets at a time, so that loading and unloading can proceed quickly. Special attention has been paid in the design to the suspension, use of non-inflammable materials, ventilation, thermal insulation, flameproof electrical installations for lighting and heating, and safety in the use of the lift. The wagon is designed for speeds of up to 140km per hour.



Two turbo sets of 32MW capacity each at Tuncbilek power station

Tuncbilek Power Station

On April 6th, the official opening took place of Tunçbilek power station in North West Anatolia, Turkey. The station, which has a capacity of 60MW, was built by a German consortium, consisting of Allgemeine Electricitäts-Gesellschaft, Dürrwerke A.G., Mannesmann-Export G.m.b.H., and Wayss and Freytag A.G.

The two steam turbo sets of 32MW each are built in unit construction and have single-cylinder, axial-flow turbines without reheat. Steam is supplied at 88 atmospheres gauge and 510 deg. Cent. Condenser vacuum is 0·065 atmospheres absolute at a temperature of the cooling water of 27 deg. Cent., with cooling of the water in hyperbolic natural convection towers.

The two alternators are laid out for 40,000kVA, 10·5kV, and 50 c/s, and are air cooled. There are two main transformers of 40,000kVA, for stepping up the voltage to 161kV, as well as two station transformers of 7500kVA, 6kV.

Switchgear includes five compressed air circuit breakers with a capacity of 2,500,000 kVA each at 161kV.

Thermal equipment consists of two radiation boilers with natural circulation, for pulverised brown coal firing with molten ash extraction. Each boiler has an output of 135 tons per hour at 110 atmospheres gauge. There are two mills, each capable of grinding 38 tons of coal per hour, supplied from an intermediate bunker situated overhead. An electrostatic dust extraction plant has been fitted with a guaranteed efficiency stated to be 98 per cent. Air for the boilers is pre-heated by means of Ljungström preheaters.

Overall design and supervision of the work were in the hands of A.E.G., which also supplied the turbo sets and all the electrical equipment. The boilers were built by Dürrwerke A.G., while Mannesmann provided the pipework and steel structures and the constructional work was carried out by Wayss and Freytag.

Output from the station will be some 300 million kilowatt-hours per annum and is to be used by the N.W. Anatolia grid, in the first instance to supply the brown coal mines of the region and the nitrogen plant which is being built in Kütahya, as well as the towns of Kütahya, Eskisehir, Bursa and Afyon.

First German Reactor

The research reactor for Munich Technical University has now been ordered from the American Machine and Foundry Company, of New York. Delivery, according to reports, is to take place in eight to ten months. How much of the auxiliary and control equipment will be bought in the U.S.A., and how much will be built locally, has not yet been decided. The reactor is to be housed in a water tank of about 4m diameter and 8m height, constructed of thick concrete, which, together with the water, will form an effective radiation shield. The core is to consist of 1 cubic metre of enriched uranium and will at first be operated at 100kW, later at 1000–2000kW, with additional water cooling.

The reactor is to be erected 16km north of Munich; its cost is estimated at about DM.1,500,000, which will be raised partly by the Federal Government and partly by Bavaria.

As regards the development of atomic energy by private industry, several leading firms are stated to be ready to form a company to be called the Kernreaktor-Finanzierungs G.m.b.H., which is to have a capital of DM.20,000,000. The firms concerned are A.E.G., Demag, Degussa, Bayer Leverkusen, Farbwerke Hoechst, Gutehoffnungshütte, Fried. Krupp, Mannesmann A.G., Metallgesellschaft, Physikalische Studiengesellschaft Düsseldorf m.b.H., and Siemens-Schuckertwerke A.G. It will be open to other firms to join this undertaking if they wish. The new company will represent the private sector in the non-profit-making Kernreaktor Bau-und Betriebsgesellschaft m.b.H., and will provide 50 per cent of the capital of DM.40,000,000, while the Federal Government and the Land of Baden-Württemberg will provide 30 and 20 per cent respectively.

The Kernreaktor Bau-und Betriebsgesellschaft is to build an atomic institute at Karlsruhe, which will house an experimental reactor. The institute is to serve as a research and training centre.

West German Locomotives

Most makers of locomotives in the German Federal Republic report a favourable state of orders which, it is said, ensures adequate employment for the coming two years. Orders from the Federal Railways are said to be increasing and to amount at present to about 60 per cent of the total order volume of DM.200 million.

Last year's production, according to a spokesman of the industry, reached a value of DM. 207 million, about DM.36,000,000 or 15 per cent less than in 1954. The total output comprised 159 million marks worth of new locomotives and 42,800,000 marks worth of accessories and spare parts. About 5,300,000 marks were earned for inspection and repair work.

Exports fell from DM.166 million in 1954 to DM.125 million last year. The principal foreign buyer last year was India (DM.61,000,000). Sales to Mozambique, which amounted to DM.14,700,000, came next. Sweden with DM.7,300,000 was the best European customer. The remaining exports went to forty-one countries all over the world.

The spokesman said one important reason for the decline in sales abroad was that some of the main buyer countries were forced to restrict their purchases abroad because of payment difficulties. Another serious difficulty was the competition from some Eastern bloc and Far Eastern countries which offered prices between 20 and 50 per cent below German quotations.

The overall raw materials supply position was described as satisfactory, except for some supply difficulties for rolled open-hearth steel. However, the industry had built up stocks of most of the raw materials needed, as manufacturers were quoting delivery periods of between nine and fifteen months.

Royal Netherlands Industries Fair, Utrecht

This year's autumn fair, which originally had been planned for the period from September 4th to 13th, will now take place from September 11th to 20th. The groups "Electric Household Goods," "Lighting" and "Radio and Television," which exhibit only once a year at Utrecht, will this time be housed on the Croeselaan site, in the Juliana and Margriet Halls, instead of in the exhibition buildings at Vredenburg.

This section occupies an exhibition space of 6300 square metres, which means an addition of 2000 square metres as compared with last year. The Efficiency Group, which, as usual, will be housed in the Bernhard Hall, occupies an area of 7000 square metres. In this section will be found equipment for offices and stores, such as office machinery and furniture, accounting systems, filing and storage systems, intercommunication systems, and stationery. Among many other groups, the autumn fair will include a medical section where medical instruments and appliances, hospital equipment and furniture and pharmaceutical preparations will be shown.

From October 9th to 17th, a special fair will be held showing machinery and apparatus for the food processing industry, the chemical and pharmaceutical industry and the dairy industry. For this fair, which, under the name of "Vochema," is organised every two years and which in 1954 occupied about 4000 square metres, applications for exhibition space totalling 8000 square metres have already been received.

Twenty-Third International Town Planning and Housing Congress

The International Federation for Housing and Town Planning (I.F.H.T.P.) will hold its twenty-third congress in Vienna during the period July 22-28th. There will be three plenary sessions, and six sectional meetings, which will be held in the New Town Hall. Concurrently, an international town planning exhibition is to take place in the Town Hall, at which exhibits from eighteen European and overseas countries will be shown; there will also be an international exhibition of books and periodicals in this field, as well as a meeting of editors-in-chief of building journals, and a competition for the best documentary film on town planning. Congress members will afterwards be able to participate in excursions through Austria. Full information can be obtained from the Secretary, I.F.H.T.P., Laan Copes van Cattenburch 123, Den Haag, Netherlands.

German Industrial Gas Turbine

It is announced that a 13·5MW gas turbine will be built by Gutehoffnungshütte A.G., Sterkrade for installation at Oberhausen. The turbine will operate on the closed cycle, with inlet temperatures of 660 deg. Cent. at the turbine and 367 deg. Cent. at the heat exchanger. It will use gas, oil or poor-quality coal as a fuel. Waste heat will be employed in a district heating system for the town. This will cost DM. 2,500,000, while the power plant itself, it is estimated, will cost DM. 6,500,000, and DM. 3,000,000 will be spent on ancillary buildings. Operating costs of the turbine set are said to be about the same as that of a 100MW high-pressure steam turbine set.

German Technical Assistance

The Federal Government expects to contribute DM.5,500,000 for technical assistance to under-developed countries in the fiscal year 1956–57. Of this amount, the Federal budget will cover DM.3,500,000, while DM.2,000,000 will come from counterpart funds. This compares with a contribution of DM.700,000 last year.

Gas-Turbine-Driven Auxiliary Electric Power Unit for Aircraft

BY OUR AMERICAN EDITOR

The Solar Aircraft Company, of San Diego, California, recently developed an airborne gas-turbine-driven auxiliary electric power unit for use on the Convair "C-131B" aircraft. The unit is installed within a streamlined pod and is designed to furnish either a.c. or d.c. electric power to the aircraft. The power units are completely independent of the aircraft engines, except for fuel supply and electric power for starting. Normally two complete pod units are used per aircraft, one mounted on the lower surface of the wing on each side of the fuselage. The pods are equipped with a complete fire detection and extinguishing system, as well as provisions for de-icing the air inlet.

THE auxiliary electric power requirements of aircraft have increased considerably in recent years. Present and future airliners will carry more passengers than before, and, coupled with increased range, will require a higher degree of passenger safety and comfort. Such items as cooking and refrigerating facilities, lighting, pressurisation and air conditioning equipment are contributing to the increased loads involved in modern airborne electrical systems. With the development of new navigational aids and communications equipment, military aircraft have been designed for all-weather operation, thus imposing greater loads on the electrical system. Such items as windshield anti-icing and defogging, propeller and spinner de-icing, and heating systems for various air inlet ducts are required in the design of all-weather aircraft. In addition, the more extensive use of electronics search, fire control and guidance equipment has contributed to the increase in the electrical loads.

Much of this electric power has to conform to rigid specifications. Wireless, radar, and navigation gear require large amounts of constant-frequency a.c. power. With a few exceptions, provisions for a constant-speed take-off have not been incorporated on main propulsion aircraft engines. The space required by a large generator often cannot be found in the limited envelope given the designer of the modern aircraft gas turbine. Finally, certain of the electric loads must be supplied when the aircraft is on the ground, at times when it is awkward and very inefficient to run up a main engine. All of these requirements have combined to create a situation which is almost impossible to satisfy with generators mounted on the main engines, and are responsible for the ever-increasing use of auxiliary power units.

The choice of a gas turbine in favour of other prime movers is usually attributed to the basic requirements of any equipment designed for aircraft use, demanding a low weight/horsepower ratio. Space is also at a premium and the small size of the gas turbine engine relative to its horsepower makes it well suited to the compact design of modern aircraft. Military aircraft are designed for all-weather operation, and such aspects of the gas turbine as ability to start and operate at low temperatures, ease of maintenance, ability to operate on a variety of fuels, and simple operating controls, all help to achieve this requirement. The high "flywheel" effect of the rotating parts of a gas turbine afford it advantages, compared with the piston engine, in maintaining good speed regulation under steep transient applications and removals of load. All these advantages easily outweigh the primary disadvantage of the gas turbine—its higher specific fuel consumption—particularly on applications where the use factor is low, as may often be the case with auxiliary power units.

Design of Power Unit

The U.S. Air Force "C-131B" aircraft was designed and is being produced by the San Diego works of Convair, a division of the General Dynamics Corporation. The "C-131B" is known as a "special mission" aeroplane, and it is being used as a test bed to prove various combinations of airborne electronic equipment. In order to satisfy all of the electric power requirements and still not handicap the aircraft with undue weight, it was decided that two gas-turbine-driven auxiliary power units would be externally mounted on the aircraft in streamlined pods. The pods are mounted on pylons provided under each wing of the aircraft, as shown in Fig. 1. Each pod is operated by individual sets of controls in the aircraft. The wiring and attaching permit the installation and operation of two pods in the following combinations: one a.c. pod and one d.c. pod, or two a.c. pods, or two d.c. pods. The design, development and production of the pods and the auxiliary power units they contain was sub-contracted by Convair to the Solar Aircraft Company, of San Diego. The attachment of each pod to the aircraft is by means of a standard bomb shackle, and provision has been made in the cockpit for jettisoning the units in case of an emergency "wheels-up" landing having to be made by the aircraft. The service connections between the aircraft and pod are of the breakaway type. They consist of a fuel connection, an electric connector for engine control and starter circuits, and electric power output connector, and grounding plug connectors.

The aerodynamic shape of the pod fairing was an effective design compromise between small size, to keep down the weight, and large L/D ratio, to keep down the aerodynamic drag. This resulted in a pod of elliptical cross-section approximately 28in by 42in, with the major axis horizontal. The need to obtain a realistic L/D ratio determined the pod length of 140in. The pylon cross-section was determined by the bomb shackle and service connections, and has a maximum chord of 11in and a length of 62in. An additional requirement concerning the external shape was introduced by the emergency jettisoning system. Under these conditions assurance was required that a free-falling pod would not strike any portion of the aircraft. This was accomplished by designing to obtain an overall pod centre of gravity well forward of the attaching lugs, and by shaping the trailing end of the pod into a flat "beaver tail." An actual drop test of a production pod, having a suitable weight substituted for the engine, was performed early in the programme to prove the design.

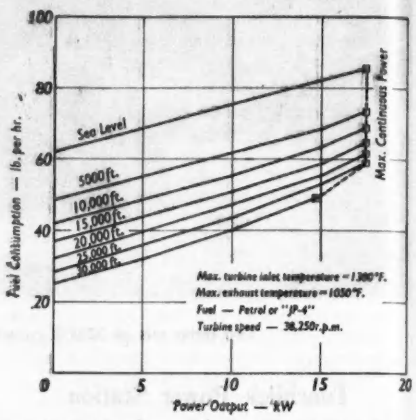


Fig. 2—Performance curves of model "T-41M-5" auxiliary d.c. power unit

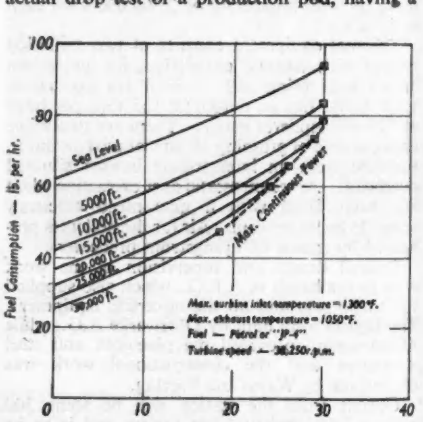


Fig. 3—Performance curves of model "T-41M-6" auxiliary a.c. power unit

The pod-mounted auxiliary power unit can be broken down into two major components: a plastic enclosure and a power plant assembly. The streamlined enclosure forming the pod consists of two parts: a forward section and an aft section, both of which are attached to a main firewall bulkhead at approximately the 34 per cent chord station. These fairings are one-piece reinforced fibreglass plastic mouldings and are quickly detachable from the internal pod structure. The design is such that with the unit mounted on the aircraft and the plastic fairings removed the power plant is completely accessible for ground maintenance, servicing and adjustment. The use of fibreglass-reinforced plastic

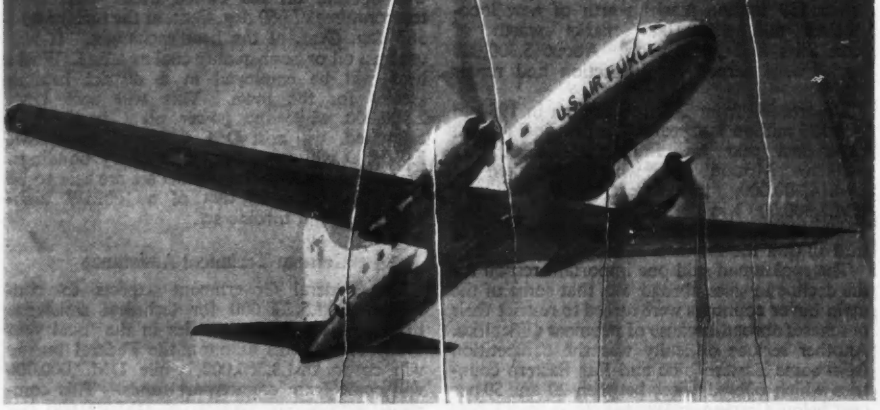


Fig. 1—Convair "C-131B" aircraft of the U.S. Air Force, with two auxiliary-electric-power-unit pods mounted underneath the wing

for the fairings resulted in a unit that is very rugged and will stand up under the abuse of ground handling and installation with a minimum of maintenance, yet is extremely light in weight.

The d.c. pod-mounted configuration has been termed the "T-41M-5" auxiliary power unit, and the a.c. configuration the "T-41M-6" unit. Figs. 2 and 3 show the performance of the units as a function of altitude, with fuel consumption at various conditions also shown. The a.c. generator set is capable of delivering at sea level a maximum continuous rating of 30kVA and an overload rating of 40kVA for five minutes. At 25,000ft, the maximum continuous rating is 24kVA. All a.c. ratings are at 0·8 power factor and 115V, three-phase 400 c/s. The d.c. generator set is rated at 28V and has a maximum continuous rating of 17·5kW from sea level to 25,000ft. The five minute overload rating at sea level is 19·6kW. In both generator sets, these ratings are for standard and hot-day conditions. In all cases, the maximum continuous power output is shown for the hot-day condition. The maximum turbine-inlet temperature is 1300 deg. Fah., and the maximum exhaust temperature is 1050 deg. Fah.

The Gas Turbine Prime Mover

Both the a.c. and d.c. generator sets are powered by a standard Solar "Mars" 50 h.p. gas turbine engine, operating at 38,250 r.p.m. This machine has a pressure ratio of 2·35 : 1, and an airflow of 2·43 lb per second. Over 360 "Mars" engines have been produced so far for auxiliary power units on other types of aircraft, and to date they have accumulated more than 200,000 operating hours in service. The unit is designed to start and operate at any altitude from sea level to 25,000ft, and in ambient temperatures ranging from −65 deg. Fah. to +130 deg. Fah. At sea level the unit can be up to full speed and carrying full load within fifteen seconds after the start switch is pressed; at 25,000ft this can be accomplished in twenty five seconds. The weight of the d.c. pod is 420 lb, and that of the a.c. pod is 450 lb. Both units are designed to use petrol conforming to the American "MIL-F-5572A" specification in the "C-131B" installation; however, they are also designed to handle "MIL-F-5624B" jet engine fuel. The overhaul period for the units at the present time is 500 hours, while routine servicing is required at sixty hour intervals.

Fig. 4 is a cut-away illustration of the "Mars" gas turbine engine. It employs a single-stage centrifugal compressor, a single elbow combustor, and a single-stage radial inflow turbine. The compressor impeller and turbine rotor are mounted back-to-back on the same shaft, and are separated by a seal plate. Inlet air enters the compressor through a screened annular opening. The scroll encircling the compressor collects compressed air delivered by the diffuser and conducts it to the combustor, where fuel is injected. Ignition, which is required only at light-off, is by spark supplied from a capacitor-discharge voltage booster. The combustion gases flow through the turbine scroll to the nozzle which directs them inward against the rotor vanes. The hot gases drive the turbine wheel and exhaust axially through the tailpipe. The compressor impeller is machined from an aluminium-alloy finger forging, while the turbine rotor is machined from a chromium-nickel steel forging. Both the inducer section of the compressor and the exducer section of the turbine rotor are formed after machining. The air-inlet case, the diffuser, and the compressor scroll are all light alloy castings. The air-inlet case and diffuser are made from aluminium alloy, while the compressor scroll is made from magnesium alloy. The nozzle box and exhaust section, including the housing for the burner, is constructed from stainless steel sheet, spot welded and fusion welded together. The burner is also of this same material, but is ceramic-coated by the "Solaramic" process.

Coupled to the turbine assembly is the reduction gear and accessory drive, which is shown in Fig. 5. The reduction is accomplished by one set of bevel gears from 38,250 to 4500 r.p.m. The advantage of a bevel gear drive in this case is that it allows the use of two main output pads at right angles to the input shaft; one output pad is stepped up from 4500 to 6000 r.p.m. so that two output speeds are available. All accessories are driven from the 4500 r.p.m. shaft through an idler gear, the idler gear driving two accessory gears. Since the idler gears, accessory gears, and main bevel gear are at right angles to the input to the gearbox, two accessory drive pads are available from each of the accessory drive gears. The four accessories drives from the accessory pads on the gearbox are the main governor-fuel pump combination, the overspeed switch, the tachometer generator and the lubricating-oil pump.

The main power transmitting gears of the gearbox are made of nickel-molybdenum steel, heat-treated, ground and lapped. The position of the main pinion bevel gear is maintained by a double-row ball bearing. The gearbox case is a magnesium casting, with steel bearing insets on the main output pads for retaining the ball bearings. All bearings in the gearbox are of anti-friction design. Lubrication of the gearbox and the turbine-rotor shaft is provided by an oil pump driven off one of the accessory pads. An integral sump is provided in the gearbox which also handles the cooling requirements of the lubricating system. No external oil cooler is used. Oil is taken from the sump by a gear pump and then delivered to the oil filter. From the oil filter, the oil goes through a relief valve and from there to the main jets. Jets are provided on the main gear mesh of the output bevel drive, the high-speed roller bearings on the main rotor shaft, and also the high-speed duplex ball bearings on the pinion end of the rotor shaft. Oil at constant pressure is supplied by the oil pump in conjunction with a relief valve.

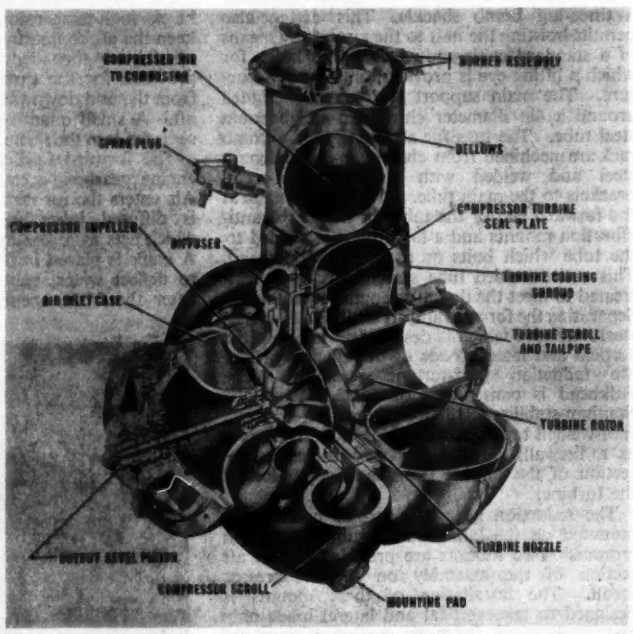


Fig. 4—Sectional illustration of 50 h.p. gas turbine engine

Engine Control System

A simplified wiring diagram of the control system is shown in Fig. 6. In order to make the control system more easily understood, safety provisions for tailpipe over-temperature, flame-out, and low oil pressure are not shown. The starting of the d.c. pod is accomplished by the d.c. generator, which is used as a motor during the starting cycle. The starter generator is mounted on the 4500 r.p.m. output pad. The starting of the a.c. generator set is provided by a separate 28V d.c. starter, which is mounted on the 4500 r.p.m. pad through an adapter plate, while the a.c. generator is mounted on the 6000 r.p.m. pad. The starting system is designed

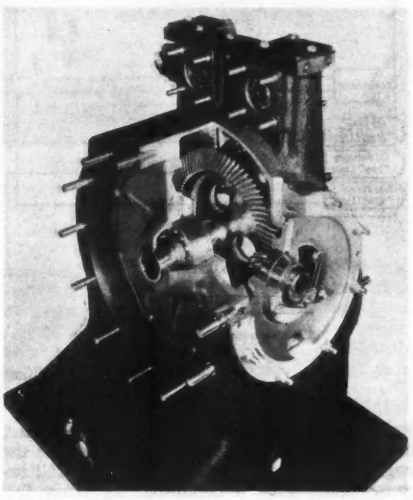


Fig. 5—Cut-away view of main reduction and accessory drive gearbox

to be completely automatic and requires only manual initiation by means of a start switch. Various pressures on the engine are sensed to sequence the starting cycle. The starting sequence is as follows:

The start switch is momentarily pressed, which latches in the starting relay. This is an ordinary electric relay, using one set of its contacts for latching. This action immediately closes the combination start contactor and drop-out relay, and the generator set starts to motor to ignition speed. Fuel pressure in the system starts to rise immediately, and presently actuates a fuel pressure switch which energises the ignition system and opens the main fuel valve. Ignition occurs and the unit continues to accelerate, fuel being metered to the turbine through the acceleration control. When self-sustaining speed is attained, the drop-out relay, sensing the starter current, opens the start contactor. The engine continues to accelerate under the influence of the acceleration control until it reaches 100 per cent speed. Slightly before 100 per cent speed is attained, the governor takes over to control constant full-speed operation. The ignition system is cut off by a pressure switch sensing the compressor-discharge pressure. When load is applied to the system, a solenoid valve is energised and by-passes the acceleration control so that full fuel flow is available.

To stop the machine, a stop switch is pressed which momentarily disconnects the electrical system from the line. This allows the start relay to unlatch and open, de-energising the main fuel solenoid valve which then closes and the unit decelerates. Safety monitoring controls are provided on the unit and will stop the machine for the following conditions: turbine over-speed, tailpipe over-temperature, low oil pressure, and burner flame-out. Visual indication is also provided for high oil temperature, low oil pressure low fuel pressure and fire warning. Over-temperature and flame-out are sensed by a chromel-alumel thermocouple in the turbine tailpipe. This temperature is indicated on the turbine control panel by an electronic pyrometer relay. The pyrometer relay is in series with the electrical latching circuit of the start relay, and when energised by unsafe conditions allows the

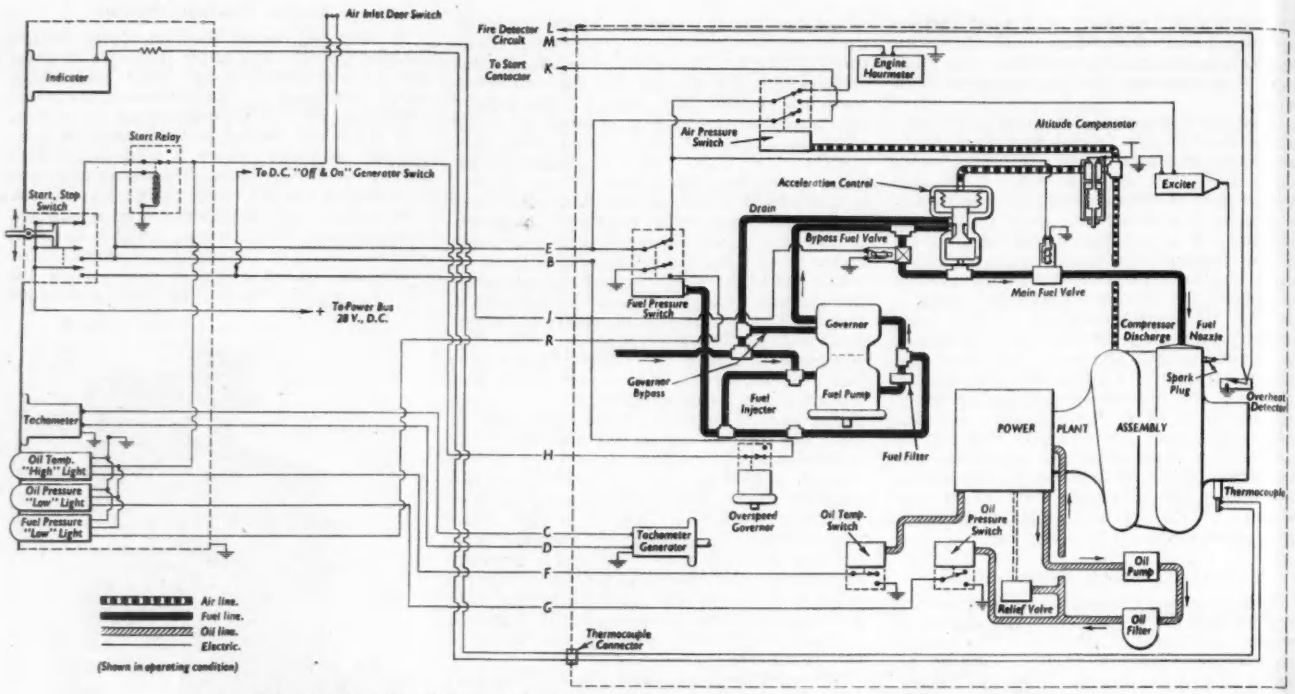


Fig. 6—Simplified wiring and flow diagram of the engine control, fuel and lubrication systems

start relay to unlatch, cutting off all electric power, closing the main fuel valve, and stopping the engine. Flame-out protection was required because under such a condition, the main fuel solenoid would remain open, and with the turbine windmilling raw fuel would continue to be pumped into the engine, creating a hazard. Turbine over-speed is sensed by a small flyweight governor acting on a snap-acting switch. This switch is in series with the latching circuit of the start relay and therefore, like the pyrometer relay, can stop the machine under unsafe conditions. The over-speed switch is set at 108 per cent speed. Low oil pressure is sensed by a pressure switch and effects engine cut-off in a manner similar to the over-speed switch and the pyrometer relay.

Design of Pod Structure

Engine-driven generator sets require a certain amount of servicing and maintenance during their lifetime. Therefore, it was important in the design to consider accessibility. Fig. 7 shows the internal structure of the pod-generator set. The design is such that only air loads are taken by the plastic fairings. All loads due to gravity and resultant air loads are distributed to the mounting hooks by means of an internal structure. Therefore, it is possible to remove the fairings while the pod is mounted on the aircraft and service the engine in this condition. Such operations as the adjustment of the speed-control system and test runs on the engine are also possible with the fairings removed.

Fig. 7—Main internal support structure of pod

The pod is attached to the airframe by a three-lug bomb shackle. This design also permits hoisting the unit to the aircraft by means of a standard cable-and-winch bomb hoist, for which a lifting eye is provided on the pod structure. The main support structure is designed around a 4in diameter chromium-molybdenum steel tube. The lugs for attaching to the bomb rack are machined from chromium-molybdenum steel and welded with suitable sheet-metal brackets to the main tube. Provision is made at the forward end of the tube for fitting the anti-vibration mounts and a large plate is welded to the tube which bolts on to the main bulkhead. This entire welded tube structure is then heat-treated to meet the design strength requirements. Separating the forward and aft shells is a stainless-steel bulkhead which is designed to take out the vertical and lateral loads of the aft supports of the reduction gear-turbine assembly. The bulkhead is constructed of A.I.S.I. type 321, titanium-stabilised 18-8, stainless steel sheet, spot-welded together. The bulkhead also serves as a firewall, since it separates the accessory section of the turbine from the hot section of the turbine.

The reduction gear and turbine assembly is mounted on the bulkhead by rubber vibration mounts. Two mounts are provided on the aft section of the assembly on the compressor scroll. The installation of these mounts is designed to take vertical and lateral loads only and apply these loads to the main attaching bulkhead. The forward end of the reduction gear and turbine assembly is retained by two rubber vibration mounts situated on the top of the gearbox. These mounts are designed to take the vertical, lateral and fore-and-aft loadings due to gravity of the reduction gear and turbine assembly.

The forward and aft fairings are one-piece mouldings constructed of fibre-glass-reinforced plastic material. This material consists of glass-fabric layers impregnated with a phenolic-base resin, and is suitable for operating temperatures up to 500 deg. Fah. The basic thickness of the shell is 0·080in with local thickening provided at the edges and at all attaching points. The aft shell contains two circular reinforcement rings having hat-shaped cross sections. A fore-and-aft vertical bulkhead is also incorporated in the trailing section of the fairing, in order to keep deflections of the flat beaver tail to a minimum. The exterior surface of both shells is finished with a filler primer and then with aluminium lacquer. The area of the aft shell in the vicinity of the exhaust pipe is finished with a black high-temperature enamel. In order to keep the aft compartment temperature as low as possible, a shrouded stainless steel tailpipe is provided for the turbine exhaust, which exists from the pod downward with a slight component aft. A small quantity of compressor discharge air is fed into the shroud for additional cooling.

The forward fairing of the pod houses the engine gearbox, accessories and the generator. Air enters the forward end of the pod, where it is diffused into the accessory compartment, which acts as a plenum chamber for the engine. A baffle is placed in the path of the entering air to deflect water, pebbles or debris that might enter the front opening. Incorporated in the

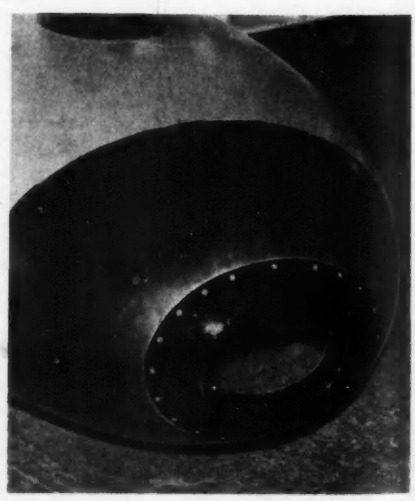


Fig. 8—External view of air inlet assembly in nose of pod

nose is an electrically-actuated door, to shut off airflow through the machine and prevent windmilling in flight when the use of the generator set is not required. The control system is designed so that the door automatically opens before the turbine begins its starting cycle; as soon as the engine is cut off, the door automatically closes. The exterior finish of most of the forward shell is aluminium lacquer; however, the forward sections of the nose and the leading edge of the pylon are finished with a synthetic rubber base rain-erosion protective coating.

The air inlet, as shown in Figs. 8 and 9, is provided with an electrical anti-icing system. Power for this is taken from the generator in the pod; therefore, either a.c. or d.c. may be used for anti-icing. To ease the problem of spare parts and maintenance, all forward fairings are identical, incorporating an anti-icing design that can handle either a.c. or d.c., depending on the pod on which the airing is used. This is accomplished by providing two heating elements in every forward fairing.

The anti-icing section of the air inlet assembly consists of a sandwich with an outer aluminium shell, a silicone-rubber blanket containing the heating coils, and an inner aluminium shell. The design is such that with the engine operating, the temperature of the inlet structure will never exceed 400 deg. Fah., even though the anti-icing switch may be inadvertently thrown on a hot day. This eliminates the use of control thermostats and provides a simpler system. The design

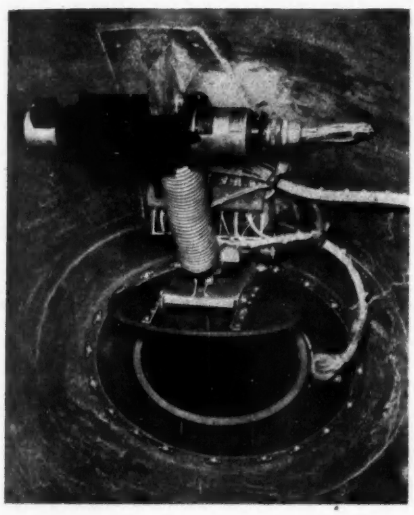


Fig. 9—Internal view of air inlet assembly in nose of pod showing door actuator and anti-icing installation

of the anti-icing blanket mounted between two aluminium shells results in a rugged assembly that is less susceptible to failure through ground-handling abuse. It also helps to withstand the deterioration produced by the situation of the pod on the aircraft. The pod is mounted within 24in of the ground and in the direct path of the propeller slipstream. When the aircraft is operated off rough or dirty runways, the pods are subjected to direct impingement of gravel and debris.

Fire Protection System

The auxiliary electric power unit is equipped with a completely self-contained fire detection and extinguishing system. The fire detectors are of the thermal switch design, one being situated in the forward engine accessory compartment, and the other one in the aft turbine compartment. The switches are wired so that continuity of the detection circuit can be checked from the cockpit. The fire detection circuit is independent of the fire extinguishing system in that it merely supplies an indication to the cockpit of high compartment temperatures.

The forward compartment of the pod contains the fire extinguishing medium: approximately 8 lb of bromochloromethane in a high-pressure spherical container. A distribution system divides the flow of the fire extinguishing medium so that both forward and aft compartments receive equal quantities. The fire extinguishing system is actuated electrically from the cockpit. The high-pressure bottle contains an explosive cartridge with a rupture disc valve. In order that large quantities of fire extinguishing medium need not be required, the through-flow of air in the compartment is stopped before the release of the medium. This is accomplished by the door in the nose of the pod; the door is spring-loaded to snap shut when triggered by an electrical signal from the cockpit in case of fire.

Absolute Calibration of the American Photoneutron Standard

The National Bureau of Standards, of Washington, D.C., has recently redetermined the emission rate of the American primary standard photoneutron source. To do this, an absolute calibration method has been developed which is more precise and more easily performed than most existing techniques. The work was conducted by the Bureau's neutron calibration group, and as a result of this study the emission rate, or "Q," previously established for the standard has been confirmed and the accuracy of the measurement increased.

The development of nuclear reactors has made possible a widespread increase in neutron irradiation research. As a result of this research a need has developed for reliable standards to calibrate accurately neutron thermal fluxes and to measure neutron yields. The N.B.S. is currently engaged in a programme to provide such standards and to establish improved methods of neutron measurement. The present re-calibration was initiated partially as a result of the wide discrepancies which have been revealed by international comparisons of neutron standards. The N.B.S. primary photoneutron standard is a radium-gamma-beryllium source that produces neutrons by the reaction of gamma rays with beryllium. The source consists of 1 curie of radium bromide in a platinum-iridium capsule that is placed in the centre of a beryllium sphere, 4cm in diameter. Since the capsule absorbs the alpha particles from radium and its decay products, only gamma rays can enter the beryllium sphere. A secondary photoneutron standard, similarly constructed and calibrated relative to the primary, is available to other laboratories for comparison measurements.

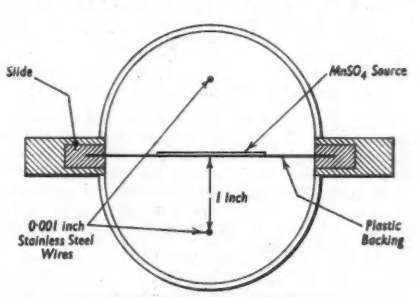
The neutron emission rate from the N.B.S. standard is more nearly constant than that from a radium-alpha-beryllium source. Sources of the latter design, which are in more general use, produce neutrons by the reaction of alpha particles with beryllium. The emission rate for such a source increases with the growth of polonium, an alpha-emitting decay product of radium. A photoneutron source, on the other hand, is not subject to this difficulty, so that its emission rate is more nearly constant over a long period of years. A decrease in emission rate does take place, but because the decrease follows the decay law of radium, it can be simply corrected for. With this primary standard other neutron sources are calibrated for Government, educational, and industrial laboratories. These sources of known strength are useful for the convenient routine checking of radiation-monitoring instruments. They are also necessary for certain cross-section measurements which predict the occurrence of particular nuclear reactions in a definite energy range.

An absolute calibration of a neutron source is the determination of its emission rate by fundamental measurements. In such a calibration the fast neutrons emitted by the source are usually slowed down by directing them into a moderating medium. The thermal-neutron capture rate in the medium is then measured. As the neutron-capture rate is equal to the emission rate the "Q" of the source is determined. Both the N.B.S. standard neutron source and the thermal neutron density have already been calibrated by methods in which the key measurement is the absolute counting rate of alpha particles from thin boron films. In the present calibration, the key measurement is the 4π counting of the absolute activity of a very thin layer of manganese sulphate. Two previous absolute calibrations of neutron sources have been made at other laboratories in which manganese sulphate solutions

Manganese sulphate bath with calibrated dip counter used in the calibration of the primary standard N.B.S. photoneutron source

were employed to moderate and absorb the emitted neutrons. Both these methods require a determination of the asbolute beta ray activity of a fairly thick layer of powder, and their precision is about 8 per cent. The accuracy obtained with the present relatively simple technique is said to be of the order of 2 per cent.

The method involves irradiation by the standard source of a large bath of manganese sulphate and the subsequent measurement of the resulting manganese activity by a calibrated dip counter as illustrated. The source is placed in the centre of a bath whose volume is large enough to make neutron leakage negligible. The neutrons are slowed down by collisions with hydrogen nuclei and are nearly all captured at thermal energies. From a knowledge of the neutron capture cross-sections and the manganese sulphate concentration the fraction (0·35) of neutrons captured by the manganese is computed. Using this fraction, and the measured activity, the emission rate of the source is determined. The dip counter is calibrated in the following manner: approximately 1 litre of the inactive manganese sulphate solution from the bath is irradiated in an intense neutron flux. The absolute activity of a small amount of this solution is then determined by 4π-counting. Concurrently, 1 litre of the activated solution is returned to the inactive solution in the large bath, the solution is stirred, and the resulting activity is measured with the dip counter. The number of radioactive manganese nuclei in the



Design of the N.B.S. 4π-counting device employed in the absolute measurement of the primary neutron standard of radioactivity

litre is obtained from the 4π determination. Thus the dip counter is calibrated by a known manganese activity.

From the present measurements a value of $1{\cdot}25_5 \times 10^6$ (± 2 per cent standard error) neutrons per second was determined for the N.B.S. standard photoneutron source. When combined with the previous independently measured value of $1{\cdot}26_5 \times 10^6$ (± 3 per cent standard error) neutrons per second, an improved value of $1{\cdot}25_5 \pm 0{\cdot}021 \times 10^6$ neutrons per second is obtained for the emission rate of the standard.

Personal and Business

Appointments

MR. S. W. COPPOCK has been appointed director of artillery (research) in the Ministry of Supply.

MR. R. I. SLATER has been appointed a director of Brightside Heating and Engineering Company, Ltd.

MR. T. A. READ has been appointed head of the legal department of F. Perkins, Ltd., Peterborough.

MR. C. J. OSBORNE has joined Lacrinoid Products, Ltd., as area sales manager for the Midlands and North England.

MR. C. F. UWINS has been elected president, and Mr. A. F. Burke, vice-president, of the Society of British Aircraft Constructors.

MR. J. C. NEVILLE has been appointed chairman, and Mr. A. T. Scales, managing director, of J. C. Neville, Ltd., 34, Priest's Bridge, London, S.W.14.

MR. H. PRYCE-JONES, manager of the Mid-Sussex area of the South Eastern Electricity Board, has been elected chairman of the Shoreham Harbour Board.

MACKAY INDUSTRIAL EQUIPMENT, Ltd., Feltham, states that Mr. A. E. Morton has been appointed sales manager (compressor division) and publicity manager.

MR. A. H. GILES has been appointed managing director, and Mr. D. V. Parker, chief designer of Heat Transfer, Ltd., 30, Church Street, Croydon, Surrey.

FORD MOTOR COMPANY, Ltd., Dagenham, states that Mr. H. A. Denne, general export manager, and Mr. F. E. W. Hammond, general supply manager, have been appointed directors.

THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH states that Mr. G. H. Greenhalgh has been appointed scientific attaché in Scandinavia. He will begin duty in Stockholm next month.

THE BRITISH TRANSPORT COMMISSION announces the following appointments :—Mr. T. H. Hollingsworth, traffic adviser at headquarters ; Mr. W. H. Smith, divisional engineer, N.W. Division (Manchester), British Road Services.

THE MINISTRY OF SUPPLY has announced the appointment of Mr. E. W. Chivers as principal superintendent of the electronics division of the Armament Research and Development Establishment, Fort Halstead, Sevenoaks, Kent.

MR. S. C. BOND, transport and shipping manager of Stanton Ironworks Company, Ltd., has been elected chairman of the National Road Transport Federation. Mr. R. G. Crowther and Mr. A. E. Brewer have been elected vice-chairmen.

THE EASTERN REGION OF BRITISH RAILWAYS states that Mr. K. B. Turner, A.M.I.C.E., has been appointed assistant engineer (works maintenance), chief civil engineer's department, King's Cross. Mr. R. A. Green, A.M.I.E.E., has been appointed signal engineer.

MR. A. K. JORDAN, assistant general sales manager of Northern Aluminium Company, Ltd., has been appointed general sales manager of Aluminum Company of Canada, Ltd. Mr. J. H. Mayes has been appointed to succeed him as assistant general sales manager of Northern Aluminium Company, Ltd.

RILEY (I.C.) PRODUCTS, Ltd., a subsidiary of International Combustion (Holdings), Ltd., states that, following the death of Mr. Vernon Young, Mr. W. Messer has become the chairman. Mr. E. W. Barnes has succeeded Mr. Messer as managing director, Mr. J. W. Wray has been appointed a director, and Mr. A. C. Syrett has been appointed general sales manager.

Business Announcements

AERO RESEARCH, Ltd., Duxford, Cambridge, states that its telephone number has been changed to Sawston 2121.

THE INTERNATIONAL ROAD FEDERATION has moved to Abbey House, Victoria Street, London, S.W.1 (Telephone, Abbey 6177).

MUREX WELDING PROCESSES, Ltd., Waltham Cross, Herts, has announced the retirement of Mr. E. J. Clarke, chief engineer, after thirty-eight years in the company's service.

THAMES BOARD MILLS, Ltd., Purfleet, Essex, has announced the retirement, on medical advice, of Mr. A. Coates, chief buyer. Mr. Coates will continue to serve the company as a consultant.

MR. J. V. FRANKLIN, managing director of Black and Decker, Ltd., Harmondsworth, Middlesex, has just returned from a month's tour of South Africa.

BRIGHTSIDE ENGINEERING HOLDINGS, Ltd., has announced the formation of a new subsidiary, Brightside Foundry and Engineering Company, Ltd., to deal with engineering and foundry activities.

THE ENGLISH ELECTRIC COMPANY, Ltd., states that all the engineering equipment which it manufactures is now distributed in Eire by Kelly and Shiel, Ltd., United Works, Distillery Road, Dublin, N.E.2.

WILLIAM DOXFORD AND SONS, Ltd., Pallion, Sunderland, has announced the formation of two wholly owned subsidiary companies : William Doxford and Sons (Shipbuilders), Ltd., and William Doxford and Sons (Engineers), Ltd.

ARMSTRONG SIDDELEY MOTORS, Ltd., Coventry, has made an agreement with Werkspoor N.V., Amsterdam, to manufacture and sell, in Great Britain and the Commonwealth, Werkspoor diesel engines for rail traction and shipping.

SAFETY PRODUCTS, Ltd., has moved to a new factory and offices at Holmethorpe Avenue, Redhill, Surrey (telephone, Redhill 4304). A small office is being retained at St. George's House, 44, Hatton Garden, London, E.C.1 (telephone, Chancery 9141).

TECHNOGRAPH PRINTED CIRCUITS, Ltd., states that its registered office and that of its subsidiary, Technograph Electronic Products, Ltd., have been moved to 207, Fleet Road, Fleet, Hants. The sales office remains at 32, Shaftesbury Avenue, London, W.1.

G. A. HARVEY AND CO. (LONDON), Ltd., Greenwich Metal Works, S.E.7, has announced the retirement of Mr. H. W. H. Icough, manager of the wirework and wire weaving departments. Mr. Icough has completed fifty years in the company's service.

MIDLAND SILICONES, Ltd., states that its electrical insulating compound MS4 is distributed in Lancashire, Cheshire, Denbigh, Flint, Westmorland and North Staffordshire by Holiday and Hemmerdinger, Ltd., 74–78, Hardman Street, Deansgate, Manchester, 3.

EDWARDS HIGH VACUUM, Ltd., Manor Royal, Crawley, and the Electric Furnace Company, Ltd., Queen's Road, Weybridge, which have been working together for some time on vacuum metallurgical problems, have announced the formation of a new company entitled Efco-Edwards Vacuum Metallurgy, Ltd.

Contracts

THE NORTH THAMES GAS BOARD has awarded a contract to Humphreys and Glasgow, Ltd., Humglas House, Carlisle Place, London, S.W.1, for the installation of four refinery gas reforming plants at Romford, Essex. The plants will be self-steaming, using the Onia-Gegi catalytic conversion process.

FERTILISERS AND CHEMICALS, TRAVANCORE, Ltd., has signed a contract with Chemiebau Dr. A. Zieren G.m.b.H., for the construction of a new sulphuric acid contact plant. The plant will utilise elemental sulphur for the production of 160 tons of monohydrate per day. In the United Kingdom the Chemiebau Zieren design of sulphuric acid plant is available through the Power-Gas Corporation, Ltd., Stockton-on-Tees.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has received an order worth more than £3,000,000 from the Central Electricity Authority for three 120MW, 3000 r.p.m. steam turbine generator sets, to be installed in Staythorpe " B " power station, now under construction on the north bank of the River Trent, near Newark. The sets will incorporate turbines of three-cylinder close-coupled design with stop-valve steam conditions of 1500 lb per square inch gauge, 1000 deg. Fah. After the h.p. cylinder the steam will be reheated to 1000 deg. Fah., then through the i.p. cylinder to the double-flow l.p. cylinder, exhausting to the condenser at a vacuum of 28·7in Hg. Six-stage feed water heating equipment will be supplied, giving a final feed water temperature of 436 deg. Fah. The generators are rated at 120MW, 0·8 p.f., and will be wound for 13·8kV, three phase, 50 c/s. They will be hydrogen cooled, using hydrogen at 30 lb per square inch, the coolers being arranged horizontally in the annular space between the core and the outside of the stator frame, which will be approximately circular in cross-section. The exciter and pilot exciter will be gear driven at 1000 r.p.m. from the main generator shaft.

Miscellanea

EMERGENCY PROCEDURES FOR WATER AUTHORITIES. —The Institution of Water Engineers, Parliament Mansions, Abbey Orchard Street, London, S.W.1, has published a report on proposals for emergency procedures in times of severe water shortage. The report was prepared by an Institution study group, and evidence was obtained from eight experienced engineers.

HOLMAN BROTHERS, Ltd.—A colour film entitled " Mobile Air Power," produced by Holman Brothers, Ltd., Camborne, was recently shown in London. The film is intended to illustrate some of the applications of the tractor-mounted air compressor unit " Tractair." It is a normal Holman compressor mounted on a Fordson Major tractor and powered from the existing rear power-take-off. Two sizes of compressor are available, both for use on the Fordson Major. Model No. 13 has the larger capacity and is rated at 110 cubic feet of free air per minute, at 100 lb per square inch. Model No. 8 supplies 71·5 cubic feet of air at the same pressure. Maximum continuous air pressure is 125 lb per square inch. These units occupy the power-take-off shaft permanently. When it is required to leave the tractor free a detachable installation, the " Holpack," is available, which is driven through a flexible coupling.

FUEL EFFICIENCY IN FOUNDRIES.—An exchange of views has recently taken place between the British Cast Iron Research Association and the National Industrial Fuel Efficiency Service to ensure that proper co-ordination exists in the technical advice both organisations offer to the ironfounding industry. It has been agreed that the two bodies can co-operate to the advantage of the industry. Through its liaison services, the B.C.I.R.A. has been successfully advising ironfounders on specific problems which are encountered in their own works. The field work on fuel that the association undertakes is mainly confined to melting and heat-treatment processes and is necessarily, therefore, smaller than that carried out by N.I.F.E.S., which has an engineering staff organised on an area basis from offices in fifteen cities in Great Britain and Northern Ireland. The B.C.I.R.A. will therefore recommend ironfounders who are concerned about the use of fuel for space-heating or steam-raising to consult N.I.F.E.S., which will in turn refer to the association any problems that fall outside its experience.

REVISED COURSE IN BOILERMAKERS' WORK.—The City and Guilds of London Institute announces the revision of the scheme for courses and examinations in Boilermakers' Work. The scheme has been prepared by a newly appointed advisory committee which includes representatives of the Water-Tube Boilermakers' Association, the Shell Boilermakers' Association, the British Transport Commission, the Institution of Mechanical Engineers, the United Society of Boilermakers, Shipbuilders and Structural Workers, the educational associations concerned with technical education, and the Ministry of Education. Students will attend part-time courses of instruction extending over four or five years. The first two or three years of the course will be occupied by preparation for the City and Guilds Intermediate examination in Fabrication of Steelwork and the last two years will be taken up by the special course in boilermakers' work. The curriculum of the latter course comprises ; workshop technique, science calculations and drawing and a scheme of workshop practice. The scheme also includes suggestions as to appropriate workshop equipment for colleges providing the courses.

STEEL EXPERTS VISIT TO RUSSIA.—As a result of arrangements made in the Steel Committee of the Economic Commission for Europe, Soviet steel experts visited the United Kingdom in December, 1954, and in return British experts visited the Soviet Union in September 1955. Both the United Kingdom and the Soviet Union subscribed at the two most recent plenary sessions of the Economic Commission for Europe to resolutions which stressed the benefits of reciprocal exchanges of production experience, and it was agreed that a further exchange if visits by steel experts should take place in 1956. The United Kingdom steel industry invited a Soviet steel delegation to visit this country in the autumn and accepted the invitation of the Ministry of Ferrous Metallurgy to send a delegation at the end of June to visit plants in the Urals Region. The delegation, which left London for Moscow on June 24th, was led by Dr. T. P. Colclough, technical adviser to the British Iron and Steel Federation. The other members are : Mr. K. C. Barraclough, Dr. C. Booth, Mr. W. O. Campbell Adamson, Mr. T. Dennison, Mr. F. Kennedy, Mr. J. A. Kilby, Mr. A. H. Meadley, Mr. R. Sewell, Mr. E. Voice, and Mr. R. Wilcock.

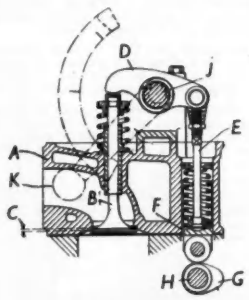
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

INTERNAL COMBUSTION ENGINES

750,441. October 5, 1953.—VALVE MECHANISMS, Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., 121, Queen Victoria Street, London, E.C.4. (*Inventor: James John Stewart Smith.*)

The invention consists in an internal combustion engine provided with inlet and/or exhaust valve operating means, including at least one rocking lever mounted for oscillation to give the movement necessary to actuate the valve or valves. For the purpose of assisting the starting of the engine, the mounting is adjustable by a single control to raise or lower the fulcrum of the lever to give, with the normal or intermediate position, a total of three positions. In one position the valve is held free of its seat, thus providing decompression; in another position the valve is operated with considerable tappet clearance, thus reducing the valve open period and providing a longer effective compression stroke and high compression of the charge, and in the intermediate position the valve operates in the manner for normal running of the engine. The mounting includes an eccentric and adjustment of the fulcrum of the rocking lever is obtained by turning the eccentric through a predetermined arc. The drawing shows a section taken through an exhaust valve operating gear of a two-stroke cycle engine adjusted for decompressed condition. The exhaust valve *A* is guided in the cylinder head *B* and is shrouded at its seat with a masking *C* of desirable depth. This masking is of particular advantage in high-speed engines, since at operating speeds it



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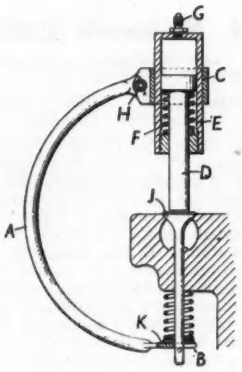
controls the effective valve period and gives the effect of a quick opening cam. The exhaust valve operating lever *D* shown in the drawing, is operated by means of a push rod *E* and tappet *F* contacting a suitable profiled cam *G* on shaft *H*. The part of the shaft *J* on which the valve lever oscillates is machined eccentrically with respect to its carrying bracket centres, so that by oscillations of shaft *J* the centre of the lever may be raised or lowered as required, in the former position to increase the valve tappet clearance or in the latter position to hold the valve at all times free of its seat. The shaft may be rotated by means of the lever *K* fixed at one end to the shaft into one of three alternative positions corresponding to "decompress," "start," or "run." To start the engine the lever is placed in the decompress position, which ensures that the valve is at all times free of its seat. After cranking the engine to a suitable maximum motoring speed the lever is moved to its start position, where a considerable valve tappet clearance is provided. This clearance considerably reduces the mechanical valve opening period, provides a longer effective compression stroke and increases the quantity of air trapped in the cylinder. An additional advantage is that the effective expansion stroke is increased. As soon as the engine starts the lever is moved to the intermediate or running position. The arrangement, which can also be applied to four-stroke engines and pressure-charged engines, is particularly advantageous when used on exhaust gas turbo-charged engines.—*June* 13, 1956.

750,562. May 21, 1954.—VALVE SPRING COMPRESSORS, Jack Wilderspin, College Farm, Fen Drayton, Cambridgeshire.

The invention relates to valve spring compressors intended for use in assembling and dismantling the inlet and exhaust valves of an internal combustion engine. Its object is to provide a new form of valve spring compressor which is simple to construct, convenient and rapid in use, leaving the operator both hands free to work, and which applies its compressive force strictly axially of the spring and valve stem. Referring to the drawing, the apparatus comprises a clamp member *A*, one end of which terminates in a fork *B* and the other end of which carries, by means of a bracket *C*, a hydraulic piston and cylinder assembly. This consists of a piston *D* working in a cylinder *E* against a coil spring *F*. A nipple *G* is attached to an oil line connecting it to a hydraulic foot pump so that on the introduction of oil through the nipple by foot pressure on the



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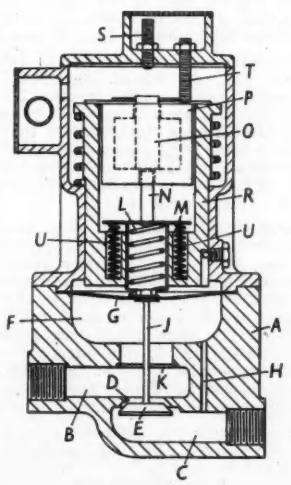
pump, the piston is moved to compress the spring. On releasing the oil pressure by releasing foot pressure on the pump, the spring causes the piston to return to its position of rest at the same time driving the oil back out of the cylinder. The piston and cylinder assembly is adjustable in the bracket *C* to allow an overall adjustment of the span of the clamp. It is locked into position by means of a screw and wing nut *H*. In the drawing a valve *J* is resting on its seating in a cylinder block. Surrounding the valve stem is a coil spring terminating in a retaining plate. A cotter pin holds the spring on the valve stem. As illustrated, the apparatus of the invention is used by locating the fork *B* underneath the plate *K* and the piston *D* on the head of the valve *J*. Hydraulic pressure is then applied from the foot pump through the nipple and causes the piston to press against the valve. Since this is already on its seating it cannot give way and the effect is to cause the whole clamp assembly to rise relative to the piston and thus compress the spring. It is then possible to withdraw the cotter pin. The valve can then be lifted away from its seating. A similar series of operations is carried out to reassemble the valve and spring.—*June* 20, 1956.

VALVES

750,620. June 24, 1953.—FLUID PRESSURE CONTROL VALVES, Industrial Control Valves, Ltd., 72, Gooch Street, Birmingham, 5. (*Inventors: Harold James Smith and William Matthew Heeley.*)

The invention relates to valves for controlling the pressure at which liquid or gaseous fuel or air is supplied to the combustion chambers of industrial



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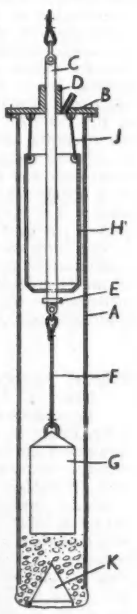
furnaces or other heating apparatus. Its object is to enable the force exerted by the spring to be varied automatically in response to a variable working condition, such as combustion chamber temperature, the supply pressure of the fuel, or the pressure of the air supplied to the combustion chamber by a blower. The drawing shows a vertical section through the valve. A body *A* is provided with an inlet passage *B* and an outlet passage *C*. Between these two passages is arranged an annular seating *D* co-operating with a closure member *E* of the poppet type. Also in the body is a chamber *F* which at one side is bounded by a flexible diaphragm *G*, and this chamber is in communication with the outlet passage *C* by way of another passage *H*. Alternatively, the chamber may be in the form of a cylinder which contains a slidable piston. The closure member *E* is connected to the diaphragm *G* by an axial stem *J* which extends across the inlet passage *B* and through a seal *K*. At the side of the diaphragm *G*, remote from the chamber *F*, is a loading spring *L* which at one end is supported on the diaphragm and at the other end is supported by an adjustable abutment *M*. According to one form of the invention the abutment has an upstanding pin *N* which bears upon the movable core *O* of a solenoid *P* mounted within a spring-loaded cylinder *R*, slidable within the body *A*. An adjustable stop *S* co-operates with the core in determining the degree of movement permitted to the abutment *M* in one direction and thereby determines the minimum pressure of the spring *L* upon the diaphragm, whilst an adjustable stop *T* determines the setting of the spring-loaded cylinder *R* and contained solenoid *P*, and thereby determines the maximum pressure which the spring *L* can exert on the diaphragm. The arrangement is such that when no current passes through the solenoid winding *P*, the abutment *M* occupies the position in which the spring *L* exerts its minimum pressure on the diaphragm. When the solenoid is excited the abutment *M* is moved to its other position, in which the spring *L* exerts its maximum pressure on the diaphragm. Springs *U* are provided between the abutment *M* and cylinder *R* to return the abutment, pin and core *O* to the stop *S* when the solenoid is de-energised. The fluid passing through the valve may be either a liquid or gaseous fuel, or it may be the air supplied by a blower, and the excitation of the solenoid *P* may be controlled by a switch operable by a thermostatic device responsive to combustion-chamber temperature or to the pressure of the fuel or air in the inlet passage.—*June* 20, 1956.

CIVIL ENGINEERING

750,762. June 29, 1954.—PILE SHOES, Heinrich Robert Hochstrasser, Am Kieselhumes, 27, Saarbrucken, Germany.

The invention relates to a method of and means for the production of shoes or tips for concrete piles, to be formed in the earth in the interior of drive tubes. In the drawing, the bore tube *A* is closed at the top by an airtight closure hood *B*. Through the hood passes a rod *C* which is sealed by a stuffing-box *D*, and is provided at the lower end with a collar *E*. A wire rope *F* connects the rod with the monkey *G*. A concrete container *H* hangs by ropes *J* from the hood *B*. A preformed cone *K* is lowered into the bore hole before the introduction of the apparatus. In operation, before being introduced into the bore hole the apparatus is suspended from a timber structure. The hood is mounted upon the collar *E*, and the concrete container upon the monkey *G*, suspended by the rope *F*, while the ropes *J* are loose. Between the upper edge of the container and the hood there is a gap which enables moist concrete to be filled into the container. The wire rope of a winch is then secured to the end of the rod *C* and the apparatus is lowered into the bore tube, but only until the hood *B* rests upon the bore tube and can be secured to it in an airtight manner. Compressed air is now introduced into the bore tube, whereby the ground water contained in the tube is forced back into the soil and, after water is expelled from the bore tube, air also penetrates into the soil surrounding the bore tube. The rod *C*, the rope *F* and the monkey *G*, with the container mounted on it, are then lowered further. After being lowered through a short distance the container *H* is held back by the two ropes *J*, the monkey liberates the lower aperture of the concrete container and the concrete falls past the monkey and fills up the lower end of the bore tube *A* above the cone *K*. This concrete is now rammed with the monkey and at the same time the bore tube is slightly raised, in order that the concrete may be able to escape laterally. After thorough ramming a pile foot is thus produced, which at the same time



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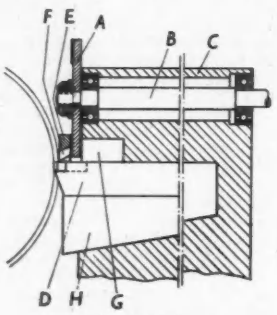
constitutes a plug which closes the pile tube. The fluid-tightness of the closure is to be ascertained from the fact that the air pressure in the bore tube rises. The entire apparatus may now be removed from the bore tube. Reinforcement may next be introduced into the bore tube, and the pile shank can be concreted, with extraction of the pile tube if desired, moist concrete being continuously rammed out of the lower end of the tube, or plastic concrete may be forced into the bore tube by compressed air.—*June* 20, 1956.

MACHINE TOOLS

750,932. November 26, 1953.—SHORTENING SHAVINGS FORMED WHEN CUTTING SCREW THREADS, The Rheinische Röhrenwerke Aktiengesellschaft, Mülheim, Ruhr, Germany.

This invention relates to means for shortening shavings formed whilst cutting screw threads in metal, particularly with hard metal single-tooth cutters. The apparatus consists essentially of a blade *A* tipped with hard metal and revolved at high speed. The blade is keyed to a shaft *B*. The shaft is mounted in ball bearings fitted in a bore formed in the tool holder or slide *C* and above the tool *D*, which pro-



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duces the cuttings and which is tipped with hard metal. A stationary blade *E* tipped with hard metal is bolted to the tool holder and provided with an opening *F* for the passage of the shavings discharged from the tool, a milled out recess *G* being provided in the holder for receiving the cut-up shavings. The tool *D* is clamped in the tool holder *C* by means of a wedge *H*. Another design is also shown in the specification.—*June* 20, 1956.

GAS TURBINES

750,555. May 7, 1954.—REDUCING HARMFUL EFFECTS OF COMBUSTION PRODUCTS, Sulzer Freres Société Anonyme, Winterthur, Switzerland.

The invention relates to a method of reducing harmful effects of certain combustion products in gas turbine plants, and is an improvement in or modification of the invention claimed in the prior application of 1954 specification No. 740,062. In that application there is claimed a method of reducing harmful effects of combustion products in a gas turbine plant which comprises adding different additional substances at at least two different points in the gas path through the plant. According to the invention, an improvement comprises introducing at a hotter point in the plant a mixture of metallic aluminium and aluminium silicate, and introducing at a cooler point in the plant aluminium silicate alone. It is preferred that the mixture contains at least 5 per cent by weight of metallic aluminium. In one form of the invention, particles of metallic aluminium in the mixture are covered with a layer of an oil-soluble substance to protect them from oxidation, in the manner known in connection with aluminium paints.—*June* 20, 1956.

METALLURGY

750,521. October 23, 1953.—THE CONVERSION OF IRON TO STEEL, Robert Edmond Warnant, 36, Avenue des Phalenes, Brussels, Belgium.

According to the invention, in a basic Bessemer conversion for the production of steel having a lower nitrogen content than that produced by blowing with atmospheric air, the temperature of the blast is always maintained above 225 deg. Cent. and, during at least half the total blowing time is blown with a mixture of oxygen and steam at a temperature between 250 deg. and 350 deg. Cent. The blast is maintained at a temperature between 250 deg. and 350 deg. Cent. during substantially the whole of the conversion. The upper limit is imposed by practical considerations only. Good preservation of the bottom of the converter can be ensured by using higher temperatures, but the cost of obtaining such high temperatures may make their use uneconomic. Preferably, the ratio of volume of oxygen to volume of steam in the blast is between 1 of oxygen to 1·5 of steam and 1·5 of oxygen to 1 of steam. The blast may also contain combustion gases, the nitrogen content of which is such that the final blast contains less than 5 per cent nitrogen and such gases may be used for preheating the steam. The steam, whether admixed with combustion gases or not, can be brought to the required temperature n a superheater. Steam thus superheated can be used to heat the oxygen to produce a mixture which enters the converter at a temperature above 225 deg. Cent.—*June* 20, 1956.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, *Park Street, London, W.*1.

P.V.C. INSULATION AND SHEATH OF ELECTRIC CELLS

No. 2746 : 1956. Price 7s. 6d.—This standard has been prepared to bring together in a single publication the methods of test and test requirements for various kinds of polyvinyl chloride insulation and sheath taken from electric cables. A colour chart giving thirteen standard colours is included. It will now be possible in future British Standards and other specifications for electric cables to give requirements for P.V.C. insulation and sheath by reference to this new standard and so to avoid quoting test methods in full. It is understood that Defence Specification DEF-9, used by Government Departments, will shortly be withdrawn in consequence of the publication of this British Standard.

NON-FERROUS CONDUIT AND CONDUIT FITTINGS (ALUMINIUM AND ZINC ALLOY).

No. 2706 : 1956. Price 6s.—The increasing use of aluminium conduit and aluminium and zinc alloy conduit fittings in both domestic and industrial installations has led to a demand for the preparation of this Standard. It covers the use of aluminium seamless tubing and aluminium and zinc alloy fittings used in conduit for electrical wiring in the same way that B.S. 31 : 1940 covers steel conduit and fittings for electrical wiring. It is, in fact, based on B.S. 31 as far as is necessary to ensure interchangeability, and the types of fittings and important dimensions of components are identical. The nomenclature, types of standard fittings and dimensions for non-ferrous conduit fittings are very similar to those for steel and iron components. In addition to the general requirements applicable to the non-ferrous alloys used, special tests are specified to ensure control of quality necessary to give safe and satisfactory service. An appendix gives recommendations for the installation of aluminium and zinc base alloy conduit and fittings. Another appendix gives recommendations for gauging.

Launches and Trial Trips

TAKORADI, tug ; built by Philip and Son, Ltd., for the Crown Agents for Oversea Governments and Administrations ; length between perpendiculars 105ft, breadth moulded 28ft 9in, depth moulded 14ft ; Kort nozzles, one 1550 gallons per minute fire pump, one 10 tons buoy lifting derrick ; machinery supplied by Plenty and Son, Ltd., consists of two sets of triple-expansion engines, each of 400 h.p. at 120 r.p.m., steam supplied at 200 lb per square inch by one single-ended oil-fired Scotch boiler. Launch, June 21st.

BOSTON BRITANNIA, trawler ; built by John Lewis and Sons, Ltd., for Boston Deep Sea Fisheries, Ltd.; length overall 122ft, breadth 24ft, depth moulded 11ft 6in, gross tonnage 220 ; fish room 6560 cubic feet, electric trawl winch of 100 b.h.p. to take 1200 fathoms of 2¼in warp ; one 20kW diesel-driven generator, one 20kW shaft-driven generator ; Widdop mark G.m.B. 6 diesel engine, 660 b.h.p. at 300 r.p.m. Launch, June 21st.

TUSCANY, closed shelter deck cargo liner ; built at Govan by Harland and Wolff, Ltd., for the Royal Mail Lines, Ltd.; length between perpendiculars 415ft, breadth moulded 58ft 6in, depth moulded to shelter deck 38ft 4in, gross tonnage 7300 ; five cargo holds, one 30-ton derrick and fourteen derricks up to 10-ton lift ; three 150kW diesel-driven generators, two vertical thimble-tube boilers ; one Harland and Wolff two-stroke, single-acting, opposed-piston oil engine, six cylinders 620mm diameter by 1870mm combined stroke, 115 r.p.m. Launch, June 21st.

NONIA, passenger and cargo ship ; built by Hall Russell and Co., Ltd., for Canadian National Railways ; length between perpendiculars 199ft, breadth moulded 35ft, depth moulded 19ft 6in, deadweight 1000 tons, strengthened for navigation in ice ; fifty first-class passengers, forty second-class passengers ; three holds, complement of 3-ton derricks ; two 100kW diesel-driven generators, one 50kW diesel-driven generator ; Fairbanks-Morse opposed-piston oil engine of 1280 h.p. drives through hydraulic coupling and reverse reduction gearing. Trial, June 28th.

ROWANMORE, cargo ship ; built at Govan by Harland and Wolff, Ltd., for the Johnston Warren Lines, Ltd.; length between perpendiculars 435ft, breadth moulded 63ft, depth moulded to shelter deck 38ft 6in, deadweight 11,000 tons on 27ft 6in draught ; two continuous decks, seven watertight bulkheads, five cargo holds, one 50-ton, four 10-ton and twelve 5-ton derricks, steam winches ; three 50kW steam-driven generators ; Harland and Wolff two-cycle, single-acting, opposed-piston oil engine, four cylinders 750mm diameter by 2000mm combined stroke, 110 r.p.m., two vertical thimble-tube boilers. Trial, June 27th.

MICHAEL C, closed shelter deck cargo ship ; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., for Andria Maritima S.A., Panama ; length between perpendiculars 435ft, breadth moulded 60ft, depth moulded to shelter deck 39ft ; five holds, one 30-ton, one 3-ton, four 5-ton and six 10-ton derricks, steam winches ; cathodic protection ; one 50kW diesel-driven generator ; trial speed 15 knots ; two multitubular boilers, Swan, Hunter-Doxford oil engine, four cylinders 670mm diameter by 2320mm combined stroke. Trial, July 4th.

Catalogues and Brochures

JACKSON AND BRADWELL, Ltd., 32, Paradise Street, Birmingham.—Folder giving details of a bench air press designed to provide a tool for the pressing of small components.

ENGLISH ELECTRIC COMPANY, Ltd., Plant Sales Department, Stafford.—Brochure giving details of a range of d.c. rail motors designed for steel works auxiliary drives and cranes, hoists, &c.

ENGLISH ELECTRIC COMPANY, Ltd., Publicity Department, Foregate Street Offices, Stafford.—Illustrated folder dealing with a comprehensive range of a.c. and d.c. motors designed especially for crane duties.

THE WALTERISATION COMPANY, Ltd., Purley Way, Croydon.—Descriptive folder giving details of "Walterisation C.I." non-rinsing iron phosphate process used as a preventative against rust and corrosion of iron and steel surfaces.

DOUGLAS KANE ASSOCIATES, 5, New Quebec Street, London, W.1.—Leaflet describing the "Burrqkik" deburring tool, with a method of deburring metal parts during fabrication without the need for a variety of tools generally used.

JAMES GORDON AND CO., Ltd., Dalston Gardens, Stanmore, Middlesex.—Leaflet dealing with a range of pneumatic power operators used for remote or automatic operation of valves, dampers, rheostats, &c., by means of compressed air.

NEWALLS INSULATION COMPANY, Ltd., Washington, County Durham.—Catalogue entitled "Heat, Cold and Sound Insulation," compiled in six sections to give concise details and technical data of this firm's products and the methods of their application.

G. A. HARVEY AND CO. (LONDON), Ltd., Woolwich Road, London, S.E.7.—List No. 965, dealing with "Rotarprest" and die-pressed ends, made in a wide range of diameters and profiles to meet modern developments in the construction of pressure and storage vessels.

F. A. HUGHES AND CO., Ltd., Devonshire House, Mayfair Place, Piccadilly, London, W.1.—Publication No. 76, describing and illustrating the various aspects of "Guardion" cathodic protection equipment, used for gas, water and petroleum installations, ships, docks and all marine undertakings, and for other forms of process plant.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTE OF MANAGEMENT

Mon., July 16th.—Management House, 8, Hill Street, London, W.1, Special Educational Meeting. Speakers, T. M. Hill and E. D. McGarry, 2.30 p.m.

CHEMICAL SOCIETY

Mon. to Thurs., July 16th to 19th.—The University College of North Staffordshire, Keele, Staffordshire, Symposium on "Chemisorption."

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., July 17th.—LONDON BRANCH : Works visit to Lafarge Aluminous Cement Company, Ltd., West Thurrock, Essex, 10.15 a.m. (Westminster Pier).

INSTITUTE OF PHYSICS

Fri., and Sat., July 13th and 14th.—NON-DESTRUCTIVE TESTING GROUP : H. H. Wills Physical Laboratory, Bristol, Summer Meeting, "Physics of Some New Aspects of Non-Destructive Testing."

INSTITUTIONS OF CIVIL, MECHANICAL AND ELECTRICAL ENGINEERS

Sat., July 14th.—MIDLAND GRADUATE AND STUDENTS SECTIONS : Joint Summer Visit to Claerwen Dam, Wales, 9 a.m. (Civic Centre, Broad Street, Birmingham).

INSTITUTION OF ELECTRICAL ENGINEERS

Sat., July 28th.—LONDON GRADUATE AND STUDENT SECTION : Summer Outing, 1956. Visit to the College of Aeronautics, Cranfield, combined with a visit to Woburn Abbey, 8.30 a.m. (Savoy Place, W.C.2.)

OLD CENTRALIANS

To-day, July 13th.—Mapleton Restaurant, 39, Coventry Street London, W.1, "Population," C. M. R. Balbi, 12.45 p.m.